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SNAKE RIVER BIRDS OF PREY RESEARCH PROJECT

ANNUAL REPORT
1975

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
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NOT FOR PUBLICATION

The data presented herein are preliminary and may be inconclusive. Permission to publish or cite any of these materials is therefore withheld pending specific authorization of the Boise District, BLM, and the specific Principal Investigator.

Michael N. Kochert
Project Leader

D. Dean Bibles
Boise District Manager

William F. Mathews
Idaho State Director

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ACKNOWLEDGMENTS

The Bureau of Land Management wishes to thank those agencies and individuals who assisted with the project. Appreciation is extended to the Idaho Fish and Game Department, the U. S. Fish and Wildlife Service; especially those personnel of Region I who helped with the Fall and Winter aerial eagle survey. Thanks is extended to Mr. Morlan Nelson for advice and technical assistance, The Cooperative Wildlife Research Unit, College of Forest, Wildlife, and Range Sciences, University of Idaho for furnishing the original background data and nest site locations, and to those individuals who volunteered their services.

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COOPERATING AGENCIES:

Idaho Fish and Game Department

U. S. Fish and Wildlife Service

SNAKE RIVER BIRDS OF PREY NATURAL AREA STAFF:

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Robert D. Rheiner	-	Bruneau Resource Area Manager
Douglas A. Smithey	-	Management Biologist, Snake River Birds of Prey Natural Area.

PREFACE

Previous work:

The Snake River Birds of Prey Natural Area (BPNA) contains the densest breeding population of raptors in the world. This exceptional raptor population continues an additional 50 miles upstream from the BPNA. It is non-existent elsewhere along the river or out in the adjacent sagebrush flats. A wealth of nest sites and an abundant prey base contribute to this phenomenal population. The BPNA and the adjacent upstream section of canyon is considered on of the most biologically unique raptor areas in existence.

The BLM became actively involved in raptor habitat preservation and management on October 12, 1971 when Secretary of the Interior Rogers C. B. Morton signed Public Land Order Number 5133 forming the BPNA. This withdrawal preserved a portion of the Snake River Canyon for the protection of nesting habitat for this raptor population. The BLM has been charged with the responsibility for land management, preservation, and enhancement of these birds and other wildlife (CFR, Title 43, Part 24 Circular 2315). Additional responsibilities are established by the Endangered Species Act of 1973 and the Critical Habitat Statement (Federal Register), April 22, 1975.

Work in the BPNA commenced when the BLM hired a research biologist in June 1972 to determine management and research needs for the area. A management biologist was hired in October 1973 to develope and implement the management alternatives outlined by research.

Many facets of the ecology in BPNA have been investigated. Sigler et al. (1972) performed an ecological survey of the area for the Idaho Water Resources Board. They made extensive flora and fauna lists, reported on past and current studies in the area, and discussed the effects of the proposed Guffey and Swan Falls dams and resulting reservoirs. Meiners (1970) and Sigler et al. (1972) also describe geologic features of the area while Goodnight (1973) surveyed the fisheries and visitor use. The U. S. Weather Service has recorded climatic data from Swan Falls, Kuna, Grand View, and Bruneau, Idaho. The U. S. Soil Conservation Service has performed extensive soil surveys on the flats north of the canyon especially in Ada County. The BLM conducted range and watershed surveys mainly on the north side of the Snake River, the most recent in 1975.

Raptor research in the BPNA and adjacent areas began in 1966 when the U. S. Fish and Wildlife Service initiated a golden eagle (Aquila chrysaetos) study in southwestern Idaho. During 1966 and 1967 they located breeding pairs and studied the nesting biology of these birds (Hickman 1968). This information laid groundwork for ecological studies on golden eagles by the Idaho Cooperative Wildlife Research Unit. During 1968 and 1969 Beecham (1970) studied productivity, nesting success, food habits, mortality, and behavior. Kochert (1972) continued the study during 1970 and 1971 and concentrated on the size,

density, distribution, and reproductive performance of the breeding population, food habits, dispersal, mortality factors, and chemical contamination. Kochert (unpublished data) continued the reproductive-performance aspects of this study in 1972.

The Idaho Cooperative Wildlife Research Unit studied prairie falcon (Falco mexicanus) reproduction, food habits and mortality during 1970-1972 (Ogden 1973). Also, incidental nesting data were collected on red-tailed hawks (Buteo jamaicensis), ferruginous hawks, (B. regalis), great horned owls (Bubo virginianus), barn owls (Tyto alba) and ravens (Corvus corax).

In fall 1972 the BLM initiated a year-round comprehensive study in the BPNA on all raptor species to gather basic information for management and research needs. Data were collected on composition and density, reproductive performance, quantitative food habits, mortality, and population dynamics of the breeding population emphasizing prairie falcons, golden eagles, red-tailed and ferruginous hawks, great horned and barn owls, and ravens (Kochert 1973a). Also, data were collected on species and age composition and density of golden eagles and other raptors in the study area. Prey base studies began at this time when BLM personnel established walking transects for jackrabbits (Ibid) and when Boise State University initiated cooperative undergraduate studies with the BLM on small rodents and Townsend ground squirrels.

Field work in 1974 in the BPNA was similar to that conducted in 1973. Data collected during these 2 field seasons provided the base-line information needed to design and conduct the Snake River Birds of Prey Research Project.

The Snake River Birds of Prey Research Project was designed when the basic research revealed that information on habitat requirements, land tenure, predator-prey relationships and life requirements of the raptors was needed to insure long-termed management and stability of this population. Thus, the Boise District, BLM submitted a research proposal (Kochert 1973b) to the Director's office in August 1973 outlining the research needs in terms of a long termed, team research project.

The Official Birds of Prey Study Area was established in April 1974 while funding for the project came in the summer and field work commenced in the winter of that year. A moratorium on most land development on Natural Resource Lands within the Study Area boundaries was declared in 1975 pending the outcome of the Research Project.

Study Area:

The official Snake River Birds of Prey Study Area lies between Walter's Ferry and Indian Cove, Idaho and encompasses approximately 755 square miles (1933 km^2) around the Snake River Canyon (Fig. i). The intensively research area within the Birds of Prey Study Area is the

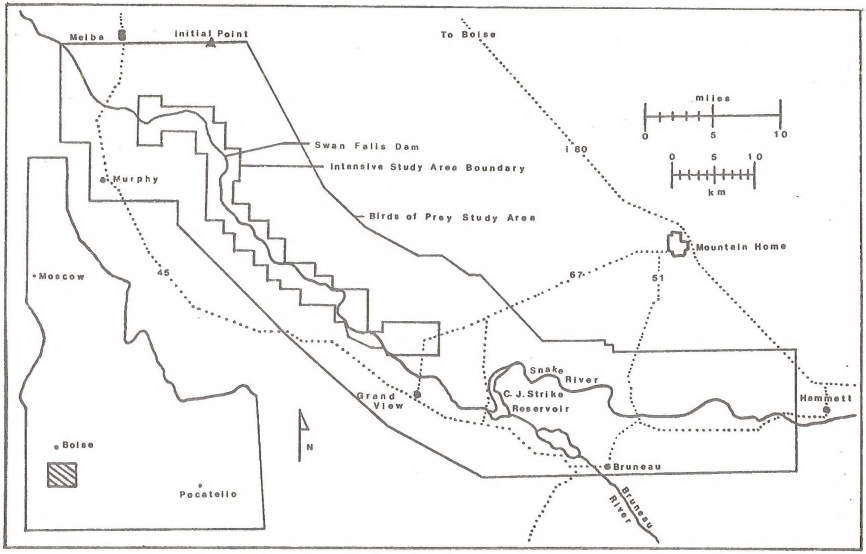


Figure 1. Snake River Birds of Prey Study Area and the Intensive Study Area.

area studied by Ogden (1973). This includes the BPNA plus an additional seven miles (11 km) southwest along the Snake River. It encompasses approximately 52 square miles (133 km^2). The BPNA is located 35 miles (56 km) south of Boise, Idaho and extends approximately 0.25 miles (0.4 km) on either side of the Snake River Canyon for 33 miles (53 km).

Intensive golden eagle nesting data were collected primarily in the Birds of Prey Study Area, although some were collected in the area used by Kochert (1972) for comparison. This area (which includes the Birds of Prey Study Area) lies between Marsing and Bliss, Idaho and extends 5 miles (8 km) either side of the Snake River (Fig. ii). Furthermore, golden eagle wintering population density and age composition data were taken from a 7,000 square mile (17,920 km^2) sample area that extends from Meridian to Rupert, Idaho (Fig. iii).

The principal geologic feature of the Birds of Prey Natural Area is the Snake River Canyon (Fig. iv). This canyon and side draws are comprised of lava and basalt overlaying softer sedimentary deposits. Cliffs range 25 to 600 feet (8 to 183 meters) with the river cutting as much as 800 feet (244 meters) below the surrounding terrain forming ideal nest sites for raptors. Topography of the Study Area is generally flat or slightly rolling with occasional low lava outcroppings (Fig. v).

The Study Area is within the Upper Sonoran Desert Life Zone and characterized by hot dry summers and mild winters. Annual precipitation averages 8 inches (20 cm) at Swan Falls. An overview of the Study Area reveals more or less descrete vegetation types. Big sage (Artemesia tridentata), white sage (Eurotia lanata), shadscale (Atriplex confertifolia), and grass (Bromus, Poa, and Agropyron spp.) communities dominate the northeast side of the canyon while Artemesia spp., greasewood (Sarcobatus vermiculatus), spiny hopsage (Gravia spinosa), shadscale, and grass communities dominate the southwest side. A narrow riparian zone is located immediately adjacent to the Snake River and permanent streams flowing into the main canyon. Sigler et al. (1972) and Meiners (1970) provide a complete physiographic and vegetative description of the area while Wilson (1975), Sigler et al. (Ibid) and Goodnight (1973) provide faunal descriptions.

Principal land uses are livestock grazing and farming. Agriculture within the Study and Natural Areas are irrigated row crops; primarily wheat, sugar beets and potatoes. Kochert (1972) determined agriculture lands comprised 18% of the golden eagle study area and Sigler et al. (1972) found 25% of the land within 0.25 mile (0.4 km) of the Snake River from Guffey Butte to Rabbit Springs was under cultivation.

Research Approach

It must be emphasized the Snake River Birds of Prey Research Project is not a loose collection of individual studies but a comprehensive intergrated work effort comprised of many disciplines forming

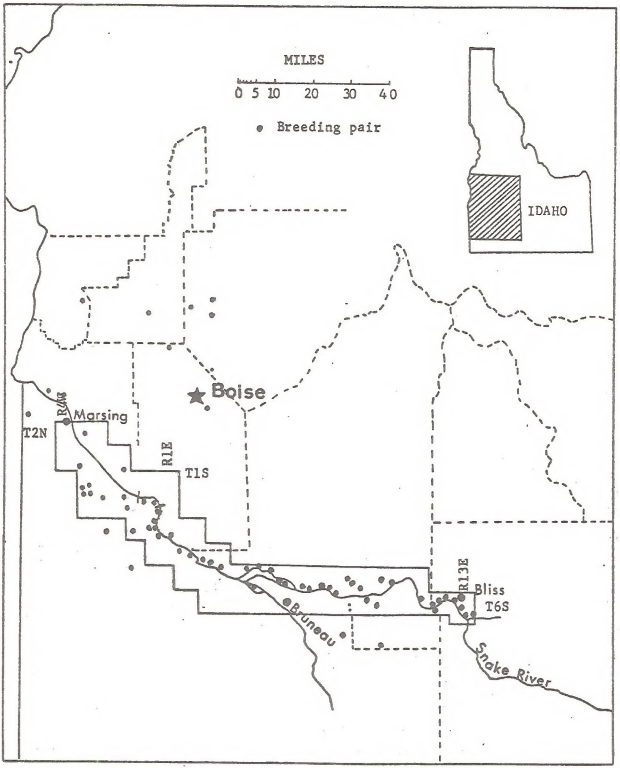


Figure ii. Map of the golden eagle study area after Kochert (1972). Heavy black lines delineate the study area.

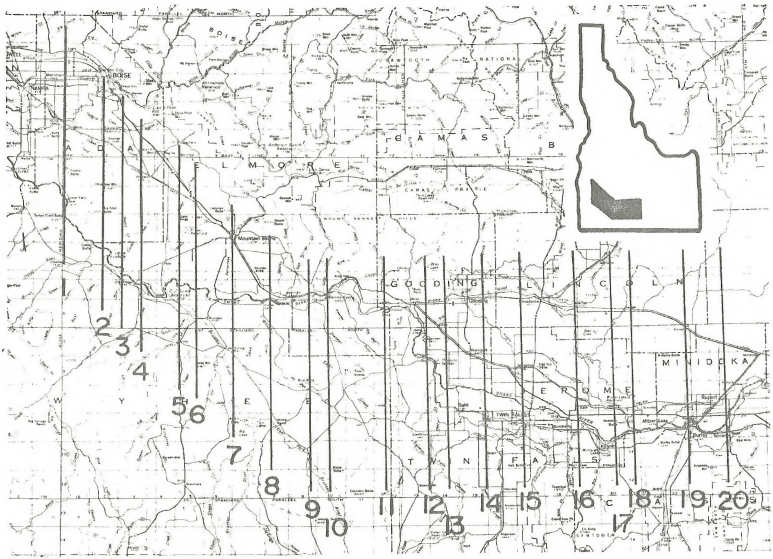


Figure iii. Location of the 7000-square mile golden eagle aerial survey with transect lines numbered.

facets (hereafter termed as studies) striving for common goals under the guidance of a single project leader. The goals or objectives of the Project are as follows:

1. Ascertain the necessary requirements in terms of habitat, successional stage, food, and space needed to sustain a breeding pair of the major raptors and rear their young.

2. Predict the effects of habitat alteration to the composition and demography of the prey base and ultimately on reproductive performance and population dynamics of the major raptors.

3. Develop a long-term management model for the BPNA and Birds of Prey Study Area.

The model in Fig. vi depicts the major ecological components upon which the project functions. It is based upon the concept that vegetation can regulate prey species composition, density and vulnerability to predation; and ultimately affect raptor population dynamics. Basically the model is structured as follows:

The vegetational component is changed through normal or human influenced succession and the resulting vegetation determines the species of birds, reptiles and small mammals present. Certain characteristics of the vegetation regulate the composition, density, and vulnerability of these prey species to raptor predation and other decimating factors (i.e. mammalian, reptilian, disease, and weather caused mortality). Raptor predation is influenced not only by the prey base but by certain raptor behavioral traits (hunting strategies, social interactions and time, energy and space budgets). Raptor predation rates and the resulting food consumption regulates raptor reproductive performance and population dynamics. Reproductive performance is the number of pairs breeding and the resulting annual increment of young that disperse from the area. Factors other than food consumption (weather, mortality, human activities) also affect reproductive performance. Population dynamics considers adult and juvenile turnover rates plus recruitment and replacement of breeders.

Eight intergrated studies (Table i) have been designed to define, test and apply components of the model. Roman numerals in the boxes of the model (Fig. vi) identify the studies working on that particular component. The research approach is divided into intensive and extensive phases. In the intensive phase high resolution data are being collected in several small areas to describe or test components of the model. By assessing prey populations in different vegetation types and applying the model we can describe the effect of various alterations upon all components of the ecosystem. In the extensive phase lower resolution data will be collected throughout the study area and phenomena described in the intensive phase will be extrapolated to the much larger and diverse area. Most work centered in the Swan Falls area in 1975 and emphasised the intensive phase so that many of the contributions are still inconclusive.

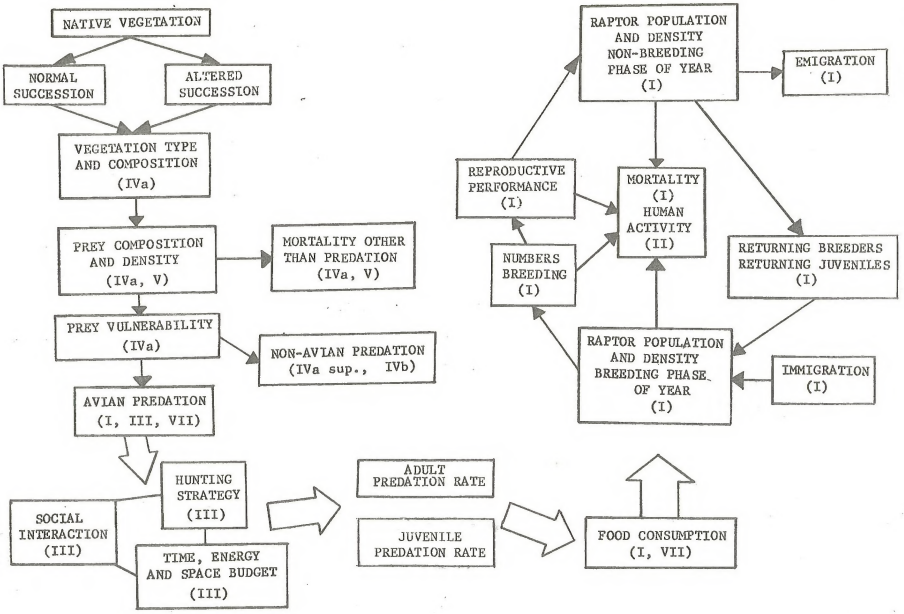

NATIVE VEGETATION
NORMAL SUCCESSION
ALTERED SUCCESSION
VEGETATION TYPE AND COMPOSITION (IVa)
PREY COMPOSITION AND DENSITY (IVa, V)
MORTALITY OTHER THAN PREDATION (IVa, V)
PREY VULNERABILITY (IVa)
NON-AVIAN PREDATION (IVa sup., IVb)
AVIAN PREDATION (I, III, VII)
HUNTING STRATEGY (III)
SOCIAL INTERACTION (III)
TIME, ENERGY AND SPACE BUDGET (III)
ADULT PREDATION RATE
JUVENILE PREDATION RATE
FOOD CONSUMPTION (I, VII)
RAPTOR POPULATION AND DENSITY NON-BREEDING PHASE OF YEAR (I)
EMIGRATION (I)
REPRODUCTIVE PERFORMANCE (I)
MORTALITY (I) HUMAN ACTIVITY (II)
NUMBERS BREEDING (I)
RETURNING BREEDERS RETURNING JUVENILES (I)
RAPTOR POPULATION AND DENSITY BREEDING PHASE OF YEAR (I)
IMMIGRATION (I)

Figure vi. Ecological model of the Birds of Prey Research Project. Roman numerals indicate the Study involved with that component.

Figure iv. Nesting cliffs along the Snake River Canyon.

Figure v. Raptor foraging habitat in the Birds of Prey Study Area.

Table i. Structure of the Snake River Birds of Prey Natural Area Research Project.

Study	Title	Principal Investigator	Affiliation
I	POPULATION DYNAMICS, REPRODUCTION BIOLOGY, AND FOOD HABITS OF RAPTORS.	Michael N. Kochert (Project Leader)	BLM
II	RESPONSES OF NESTING RAPTORS TO HUMAN DISTURBANCE	Dr. Steven R. Peterson	Dept. of Wildlife Resources, University of Idaho
III	ACTIVITY, HUNTING PATTERNS, TERRITORIALITY, AND SOCIAL INTERACTIONS OF BIRDS OF PREY.	Dr. Thomas C. Dunstan	Western Illinois University
IVa	DENSITY AND SPECIES COMPOSITION OF SMALL MAMMALS AND BIRDS.	Drs. Michael L. Wolfe and John Neuhold	Utah State University
IVaS	ECOLOGY OF REPTILES IN THE SNAKE RIVER BIRDS OF PREY NATURAL AREA.	Dr. Donald R. Johnson and Mr. Lowell Diller	Dept. of Biology University of Idaho
IVb	DYNAMICS OF NON-AVIAN PREDATION UPON THE RAPTOR PREY BASE.	Dr. Maurice Hornocker	Idaho Cooperative Wildlife Research Unit, University of Idaho
V.	POPULATION ECOLOGY AND HABITAT REQUIREMENTS OF TOWNSEND GROUND SQUIRRELS.	Dr. Donald R. Johnson	Dept. of Biological Science, University of Idaho
VI	INVENTORY AND ANALYSIS OF CRITICAL PEREGRINE FALCON HABITAT IN REGARD TO POSSIBLE REINTRODUCTION IN IDAHO.	Morlan Nelson	Private Consultant
VII	RAPTOR NESTING AND FEEDING BEHAVIOR.	Dr. Steven R. Peterson	Dept. of Wildlife Resources, University of Idaho

Literature Cited:

Beecham, J. J. 1970. Nesting ecology of the golden eagle in southwestern Idaho. M.S. thesis. Univ. of Idaho, Moscow. 48pp.

Goodnight, W. 1973. Wildlife and the Swan Falls-Guffey Project. Idaho Wildl. Review, Idaho Fish and Game Dept. 26(1):3-6.

Hickman, G. L. 1968. The ecology and breeding biology of the golden eagle in southwestern Idaho and southeastern Oregon. U.S. Bureau Sport Fish. and Wildl. Unpubl. rep.

Kochert, M. N. 1972. Population status and chemical contamination in golden eagles in southwestern Idaho. M.S. thesis. Univ. of Idaho, Moscow. 102 pp.

_____. 1973a. Density, food habits, and reproductive performance of raptors in the Snake River Birds of Prey Natural Area. Annual Progress Report. Bureau of Land Management. Boise District, Idaho.

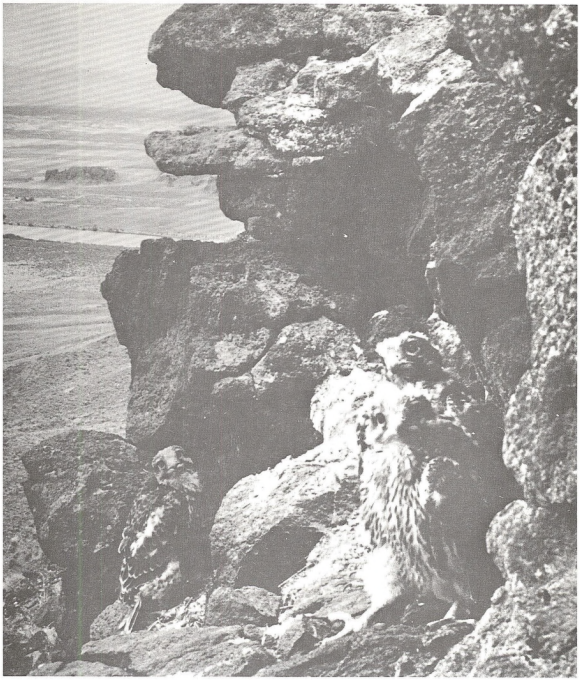
_____. 1973b. Predation ecology and population dynamics of raptors in the Snake River Birds of Prey Natural Area. A research proposal on file Boise District, BLM.

Meiners, W. R. 1970. Snake River Birds of Prey Natural Area - a protective withdrawal. Rept. to the Director BLM, Boise District, BLM. 48pp.

Ogden, V. T. 1973. Nesting density and reproductive success of the prairie falcon (Falco mexicanus) in southwestern Idaho. M.S. thesis Univ. of Idaho, Moscow. 43 pp.

Sigler, W. F., M. L. Wolfe, W. T. Helm, and J. M. Neuhold. 1972. The potential and assessment of mitigation of Swan Falls and Guffey Dams on the Snake River ecosystem. Rept. to Idaho Water Resources Board. Utah State Univ., Logan. 87pp.

Wilson, L. O. 1975. Distribution, season of use, and habitat of the mammals, birds, reptiles, amphibians and fishes of Idaho. U. S. BLM Report, Idaho. 132pp.



Fledgling prairie falcons in the Birds of Prey Study Area.

Study I: Reproductive performance, food habits, and population dynamics of raptors in the Snake River Birds of Prey Natural Area.

Investigators:

Michael N. Kochert	- Principal Investigator
Albert R. Bammann	- Assistant Research Biologist
Richard P. Howard	- Research Assistant
John H. Doremus	- Research Assistant
Michael Delate	- Research Technician
Debby Donahue	- Research Technician

Project Support: BLM "In house" study.

Objectives:

1. To annually determine absolute nesting density and reproductive performance of the major nesting raptors.

2. To annually ascertain quantitatively food habits of the major nesting raptors and to attempt to estimate absolute food intake for select species.

3. To ascertain seasonal species composition, population densities, age compositions and mortality rates of raptors within the study area.

Annual Summary:

Studies on the population, phenology and reproductive success of the most ecologically significant birds of prey within the Study Area were conducted. We collected food habits data from specific nests and determined prey species captured in relation to habitat type. Pesticide and mercuric contamination of raptors and prey species was determined. Monthly transects of birds of prey in and around the Natural Area, and winter and fall transects of golden eagles (Aquila chrysaetos) and black-tailed jackrabbits (Lepus californicus) in and near the Study Area were conducted.

Plans for 1976 Field Season:

Monthly road transects, winter and fall golden eagle and jackrabbit transects will be conducted as in past years. The Study Area will be periodically surveyed beginning in January to determine arrival date of migratory species and other phenological data. When territorial or courtship behavior is first observed visits will increase.

The number of individual pairs of each species to be observed for reproductive phenology and breeding success will be 20 prairie falcons and 10 each for golden eagles, red-tailed hawks (Buteo jamaicensis) and ravens (Corvus corax). Data will be recorded on other breeding species as pairs are located and all traditional sites will be visited. The total inventory of all breeding pairs throughout the Study Area

may be reduced to an inventory only in a representative portion to determine trend. Food habits collections will be made on 10 sites for each species plus comparative collections will be made on pairs located in unique habitats.

Banding and color marking will continue. Data now being collected on golden eagles marked in 1970 and 71 has demonstrated the value of this work. An effort will be made to capture and band adult breeding raptors to determine if birds return to the same territory each year.

METHODS

Nesting Population

Nesting data were collected following the procedures outlined by Craighead and Craighead (1956), Smith and Murphy (1973) and Kochert (1973). Occupied sites were located by systematically searching potential areas throughout the nesting season on foot and by boat. We located active nests by observing courtship and brood rearing activity of the adults or conspicuous field sign (i.e. fresh white wash, fresh nesting material or presence of young). The task became extremely tedious and time consuming when non-breeding pairs occupied a site. This necessitated numerous visits to confirm if eggs were laid. All decorated or potentially active nests were entered, examined for eggs, eggshell fragments, dead young or any sign of activity.

A "site" refers to area of cliff or a group of nests that were used in this or in previous years by a mated pair of birds. An "occupied site" or "pair" is any previously known site occupied by a pair of raptors or a cliff defended by one or two adult raptors at any time during this breeding season (Fyfe et al. 1969). A "nesting attempt" is a site that contained an incubating adult, eggs, young or any field sign that indicated eggs were laid regardless of success. A nesting attempt was considered successful if one or more young reached fledging age: i.e. the age at which most young of that species are capable of flight. Active golden eagle and buteo nests discovered after young might have fledged were considered successful if there was a sufficient quantity of white wash around and below the nest, the nest platform was well worn and contained prey remains, and no dead young birds were found within a 50 meter radius of the nest.

Breeding phenology was obtained from weekly visits to traditional nest sites beginning in January. The breeding season began when the adults actively engaged in courtship display and lasted until the last young departed from the vicinity of the nest or became self sufficient. Since golden eagles and great horned owls (Bubo virginianus) are year-round residents, only initiation of courtships was considered. "Courtship" as used in this study refers to that activity usually associated with pair bonding, territorial defense, or reproduction by one or more adult birds in the vicinity of a potential nest site. We avoided checking nests immediately after hatching to minimize nest desertion and chick loss (Fyfe and Olendorff 1976). Thus, laying and hatch dates were usually determined by back-dating from estimated ages of young nestlings. However, some known hatch dates were obtained. Growth rates of these known aged juveniles were used to help estimate age of other juveniles of that species. Because of the loose nest attachment of ferruginous hawks (Buteo regalis), nests were not disturbed until nestlings were several weeks old - beyond the age they could be precisely aged. Average laying, hatching and fledging dates were determined by calculating average Julian dates for these events.

Selected nesting sites were visited at least weekly until early September to assess occupancy (presence of adults or juveniles), and determine disperal. For the remainder of the fall and winter the study area was visited at least monthly.

During the breeding season twenty-eight intensively studied nests were visited at 4 day intervals. Less intensively studied nests were visited weekly. Others were observed to verify occupation of territory and/or nesting attempt and to confirm fledging. All nests were entered via standard rappelling techniques (Fig. 1).

Reproductive data collected consisted of clutch size, maximum brood, fledging success, and chick mortality factors. "Maximum brood" (Olendorff 1973), the maximum observed number of hatching chicks in a nesting attempt, places early nestling mortality in the same classification as embryonic mortality. However, we assessed maximum brood size only in those nests where chicks were less than 10 days old to minimize this bias.

Nestling raptors and ravens were banded with U.S. Fish and Wildlife Service leg bands. All birds banded by personnel in Study III were under the BLM Master Station Permit and their data is included in our totals. Banded birds were weighed with a Chattilon spring balance, and their foot pad from tip of the middle toe to the tip of the hallux was measured in order to obtain sex ratios for at least the eagles and red-tailed hawks (Kochert and Seidensticker In Prep.).

All banded juvenile golden eagles, red-tailed and ferruginous hawks, and ravens and some prairie falcons (Falco mexicanus) were fitted with yellow vinyl wing markers (Fig. 2). Markers were placed on the left wing of eagles and the right wing of the other species. Additionally, recticies or remiges of individuals were painted with an acrylic base fabric paint (Artex and Vogart) for specific identification. Wing markers for the smaller birds were made from Herculite 50 and eagle and large buteo markers from Herculite 80. All markers were crescent shaped as design by Kochert (In Prep.). Marker dimensions were 127 x 275 mm for golden eagles, 71 x 180 mm for red-tailed hawks and ravens, 75 x 190 mm for ferruginous hawks and 64 x 170 mm for prairie falcons. Over 600 requests for information on sighting of marked raptors were prepared and distributed to state, federal and local agencies and organizations in the western United States (Fig. 3).

Dead nestlings and unhatched eggs were collected to determine cause of death. We examined decomposed nestlings in the field and collected fresh carcasses for autopsy. All dead raptors located throughout the study area were examined. Causes of mortality often could not be determined when juveniles were missing from nests unless there was evidence of predation. All unhatched eggs were examined for embryos.

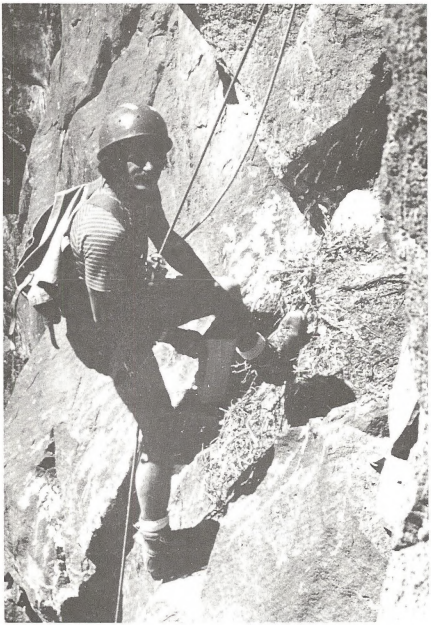


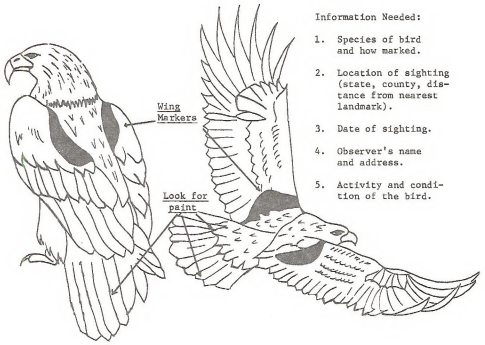
Figure 1. Research biologist Study I rappelling into red-tailed hawk nest.

Figure 2. Nestling golden eagles with wing markers.

WANTED ALIVE

INFORMATION NEEDED ON COLOR-MARKED BIRDS OF PREY

Research personnel at the Snake River Birds of Prey Natural Area would like your help in recording birds-of-prey movements. We have placed color-coded vinyl wing markers and/or yellow "paint" on juvenile birds of prey to help determine post-fledgling movement. Wing markers and tail paint, as illustrated, may show only on the dorsal surface of the birds. Ninety-three birds (golden eagles, prairie falcons, red-tailed hawks and ravens) were marked this year and the program will continue until 1980.



Information Needed:

1. Species of bird and how marked.
2. Location of sighting (state, county, distance from nearest landmark).
3. Date of sighting.
4. Observer's name and address.
5. Activity and condition of the bird.

Please send to:

Dean Bibles, District Manager
Boise District, Attn: Mike Kochert
Bureau of Land Management
230 Collins Road, Boise, Idaho 83702

Phones:
Commercial - 208-342-2711, Ext. 2582
FTS - 208-342-2582

Figure 3. Request for information on marked birds.

Food Habits

Food habits for golden eagles, prairie falcons, red-tailed hawks, and ravens were determined by analysis of castings (regurgitated pellets) and prey remains collected from nests visited every 4 days. Edible remains were identified as to species, sex and age class; marked by removing the head, feet and tail; and left in the nest. Food habits of great horned and barn owls (Tyto alba) were ascertained from fresh casting collected on periodic visits to roosts.

Prey remains and castings were analyzed by Mr. Jackson Whitman at the University of Idaho and by BLM research staff. We calculated prey numbers in the castings from a maximum count of femurs and/or mandibles. Counts of mandibles or skull parts alone are not accurate since some species (ravens and prairie falcons) sometimes do not consume the heads of their prey.

All prey individuals were stratified into age and sex classes. An average weight figure was assigned to each age and sex class and prey biomass calculated (see Appendix 1). Individuals of unknown size and age classes were assigned an average weight.

We placed a time lapse movie camera in the nest of a pair of prairie falcons, golden eagles, and red-tailed hawks (Fig. 4). The camera-intervolometer units, (Telonics Co., Mesa, Arizona 85203) consisted of a super-8 Minolta movie camera, an intervolometer unit controlled by togal and thumbnail switches, an extraprogramable run, and photo-electra cell. The units were contained in a weather proof aluminum container and were adapted for an external triggering device: either a hand held Citizen's Band (CB) radio transmitter (Fig. 4), or a RF Doppler radar movement detection device. All film was duplicated and the originals stored in a refrigerated container until analyzed.

A radio controlled camera unit in the prairie falcon nest was adjusted to shoot one frame per second for 5 minutes. The camera was placed on a ledge adjacent and on the same level to and 3 meters from the scrape. Personnel from Study VII observed the eyrie from dawn to dusk and triggered the camera each time an adult entered the scrape with prey.

One camera each was placed in a golden eagle eyrie and red-tailed hawk eyrie. These cameras were set on straight time lapse and shot 1 frame per minute. Film was changed every four days.

Raptor Populations

Seasonal raptor trends were monitored monthly by a 70 mile raptor road transect (Kochert 1973). Raptor species, age, sex composition and numbers within 0.25 mile (0.4 km) of the vehicle were recorded as well as vegetational type occupied and activity of the birds. The transect was run between 11 and 15 of each month at

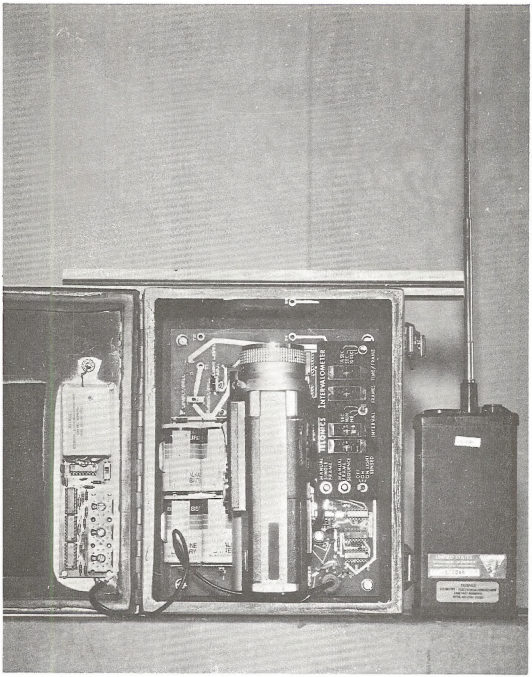


Figure 4. Remote operated movie camera and CB triggering device.

a speed between 15 and 25 mph (24 and 40 kmph). Actual dates for the transect were selected for uniform weather conditions. Ravens and shrikes (Lanius spp.) were included in the survey as they compete with raptors for food and/or nest sites.

Golden eagle aerial transects were flown in January or February and October over 7,000 square miles (17,920 square km.) of the Snake River flood plain from Meridian east to Rupert, Idaho (Fig. iii). The area was sampled via 20 random NS 50 mile (80 km.) transect from a fixed-wing aircraft. Golden and bald eagles (Haliaeetus leucocephalus) within 0.25 mile (0.4 km.) of the transect route were recorded and aged, and other raptor species and coyotes (Canis latrans) were noted.

Pesticide Analysis

We prepared egg, feather, and tissue samples of ravens, major raptors, and their prey for organchlorine and mercury analysis. Eggs were collected from abandoned nests or were those that failed to hatch. Feather samples were obtained by clipping small sections from live eagles when they were banded. Tissue samples of prey species were taken from remains in eagle nests. Eagle feather and prey tissue samples were taken from nests where similar samples were taken in 1971 (Kochert 1972) to determine if any change in mercury levels has occurred.

Before extracting egg contents we followed the procedure outlined by Ratcliffe (1970: 111-113). Outer dimensions of each egg were measured to the nearest 0.1 mm, then the eggshells were dried at room temperature and weighed to the nearest 0.1 gm and the Ratcliff index calculated. The Idaho Department of Health and Welfare, Bureau of Laboratories analyzed samples for oganochlorine residues using liquid gaschromatography, and for total mercury using flameless atomic absorption spectometry. Thompson (1974) and Shields et al. (1971) describe sample preparation and analytical procedure for organochlorine and mercury analysis respectively.

Jackrabbit Transects

Jackrabbit transects were run in conjunction with personnel from Study IVa. Methods and results are presented by Montan 1975.

RESULTS

The Nesting Population

We located 49 pairs of ravens and 214 pairs of 11 raptor species in the intensive study area: prairie falcon, 117 pairs; golden eagle, 14; red-tailed hawk, 28; American kestrel (sparrow hawk) (Falco

sparverius), 17; great horned owl, 16; barn owl, 3; ferruginous hawk, 7; marsh hawk (Circus cyaneus), 7; screech owl (Otus asio), 1; burrowing owl (Speotyto cunicularia), 2; and long-eared owl (Asio otus), 1. While we only located 3 pairs of barn owls at least 19 sites were identified in 1973 (Kochert 1973). Of 3 previously identified long-eared owl sites only one was occupied in 1975. While short-eared owls (Asio flammeus) have nested in the area no sites were found. These inconspicuous ground nesters locate in habitats not intensively searched and possibly were missed.

Golden eagles, prairie falcons, red-tailed hawks, and ravens comprised 80% of the nesting pairs. Prairie falcons, the most numerous species, represented 45% of the nesting population. Ravens, the next most numerous, comprised 18%.

We surveyed the 45 mile (72 km.) extensive study portion of the Birds of Prey Study Area (Grandview to the Indian Cove Bridge) in March and June for golden eagles, red-tailed hawks, prairie falcons and ravens. A total of 48 prairie falcons, 12 golden eagles, 18 red-tailed hawks, and 17 raven occupied sites were identified.

A 36 mile (58 km.) stretch of the Snake River from Hammett to the mouth of the Malad River (Fig. ii) was surveyed for prairie falcon occupied sites; only 4 sites were located. The survey was done in only a few days in June and we probably missed some sites. However, the difference between the prairie falcon density observed in the intensive study area and this area is obvious.

Nesting Density

Collectively, the 263 pairs of raptors and ravens averaged 5.1 pairs per square mile based on the arbitrary limits set on the 52 square mile study area. This density is slightly greater than that reported for this population in 1973 (Kochert 1973) which is greater than any density reported elsewhere. On a linear basis the 40 mile long intensively study area contained an average of 6.6 raptor and/or raven pairs per mile (4.1 pairs per km) or 1 pair per 267 yds. (294 m). This increase in density probably results from an increased knowledge of the Study Area.

We calculated average minimum distance (Ratcliff 1962), between nesting attempts of the major species. In the case of non-breeding pairs we measured from the most active roost or the most recently active site. Prairie falcons on the south side of the Snake River averaged 724 m (range 80-2975) between sites and 766 m (range 150-2500) on the north side. Nesting density was the greatest on the north side between Halverson Lake and Swan Falls Dam (11 miles or 17.6 km distance) where sites averged 432 m (range 150-1175) apart. Ravens (both north and south of the river) averaged 1444 m (range 300-7750) between sites while red-tailed hawks averaged 2320 m (1.4 miles) in the same area. Golden eagle pairs average 4340 m (2.7 miles) apart (range 2180-6640 m).

Nesting Phenology

Due to the size of the task and lack of personnel at the beginning of the nesting season we were not able to obtain breeding phenology data on all species. However, we obtained data for the six most common and ecologically significant species (Table 1).

As in previous years golden eagles and great horned owls were the first to initate nesting activity. We first recorded courtship on 2 and 3 February respectively for great horned owls and golden eagles. However, by back dating 31 days from the first laying dates (Smith and Murphy 1973:11-12) courtship for these species actually began in early January. Ravens, which also occupy the area year around, did not actively engage in courtship until mid-February.

Prairie falcons were the first migrant raptor species to arrive in the Study Area (January 21), and their arrival varied little from the dates they were first observed in previous years. A month later the first red-tailed hawk territorial defense was observed. Ferruginous hawks were observed on a breeding site in early March. It is possible some red-tailed and ferruginous hawks were establishing a breeding territory earlier but were missed. First recorded kestrel and marsh hawk courtship was observed in late February and early March respectively.

Nesting sites of migrant species (prairie falcons, red-tailed and ferruginous hawks) often would first be occupied by a lone bird. However, within a few days or weeks a second bird would arrive. Courtship began immediately upon arrival of the second bird and intensified during the following weeks. All species were establishing territory and engaging in reproductive activities by mid-March. All species displayed some form of courtship behavior throughout the entire nesting season; however, it was most intense at the beginning of the nest construction and during the egg laying period.

To obtain egg laying dates we back dated from hatching 45 days for golden eagles (Beecham 1970) and 30 days for prairie falcons, red-tailed hawks, ravens and great horned owls (Smith and Murphy, 1973, Bent 1938). Average egg laying and hatch dates for eagles was a week earlier than 1974 but similar to 1973 and a week later than 1970 and 1971. Prairie falcon laying and hatch dates were similar to previous years. The same parameters for red-tailed hawks in 1975 were similar to 1973 but a week later than 1974. Ravens laid eggs and hatched young at least a week earlier than 1974. Great horned owls nesting was at least a week later in 1975 than previous years. The great horned owl figures may be biased because of a small sample size this year.

Table 1. Nesting phenology of the six major nesting raptors, Snake River Birds of Prey, Natural Area, 1975

Species	First Arrival and Courtship	Laying $\bar{x}$ (range)	Hatch $\bar{x}$ (range)	Fledge $\bar{x}$ (range)	First Young Dispersed	Last Young Seen	Last Adult Seen	Length of Breeding Season
Golden eagle	II/3	III/6 (II/9-III/26)	IV/20[1] (III/25-V/10)	VI/18[2] (V/23-VII/10)	VIII/12	VIII/13 XII/31**	+	234
Red-tailed hawk	II/22	IV/9 (III/24-IV/26)	V/8[3] (IV/22-V/25)	VI/9[4] (V/30-VII/8)	VII/9	VIII/5	VIII/12	164
Prairie falcon	I/21	IV/7 (III/29-V/20)	V/7[5] (IV/28-VI/19)	VI/10[6] (V/30-VI/28)	VI/28	VII/21	VII/28	181
Ferruginous hawk	III/5	--- (---)	--- (---)	VI/18[7] (VI/13-VI/20)	Early VII	VII/15	VII/21	133
Raven	II/13	III/29 (III/1-IV/18)	IV/30[8] (IV/2-V/20)	VI/3[9] (V/12-VII/9*)	V/26	VII/27	+	164
Great horned owl	II/2	--- (---)	III/31[10] (III/29-IV/3)	V/19[11] (V/13-VI/7)	---	VII/29	VIII/5+	201

* renesting
** radioed bird Study III
\+ year round residents

1 20 dates
2 25 dates
3 35 dates
4 38 dates
5 56 dates
6 120 dates
7 7 dates
8 37 dates
9 70 dates
10 6 dates
11 10 dates

Young great horned owls began to fledge in mid-May and the first golden eagle fledged soon after. The entire duration of fledging by all species was two months. This was comparable to the duration observed in previous years for all species except ravens and great horned owls. Fledging duration was three weeks longer for ravens and fledging was two weeks later for great horned owls.

Juvenile ravens began to disperse from the vicinity of the Snake River Canyon in late May. While juvenile dispersal occurred during a period of 57 days individual broods of ravens were sighted near the nest site no longer than 2 weeks after fledging. It appeared that they moved as groups out of the canyon into the surrounding area but not necessarily as family units. Marked young ravens were sighted in groups with many unmarked ravens. Adult raven pairs were observed in the vicinity of nest sites in late August although the sites were vacant immediately following juvenile dispersal.

Prairie falcons were the next species to disperse from the nesting area (late June) and like ravens they left soon after fledging. No young were known to have remained near their natal site over 30 days after fledging. All young falcons and adults had left the canyon by 28 July.

Young red-tailed hawks dispersed from the nesting area within 27-41 days after fledging. They remained near the Snake River Canyon until early July and by mid-August all young and adult red-tailed hawks were gone from the Study Area.

The last great-horned owl young was sighted near a nesting site on 29 July (77 days after fledging), and the last adult was observed 5 August. This species occupies the area year around and it is possible young and adults were in the canyon after these dates but had moved from the nest sites or were missed.

The first evidence of golden eagle dispersal was a sighting of a marked juvenile 3.4 miles (5.4 km) from the nearest nesting site. A juvenile color marked in 1975 was found dead in Elko County, Nevada in mid-November: approximately 4 months after fledging and 100 miles (160 km) from the Study Area. However, another color-marked juvenile was sighted on 5 December 1975, approximately 2 miles (3.2 km) from the nearest active nest site. One radioed juvenile golden eagle was still within a few miles of the nest site on 31 December (Dunstan and Harper 1975). Past movement information on this population (Kochert unpublished), indicates juvenile dispersal is almost random. Adult eagles are sighted near eyries all months of the year.

Red-tailed hawk and prairie falcon fledging dates apparently determine the duration of the post-fledging period. An early fledged red-tailed hawk remained in the nesting area 41 days while the latest

fledged young was observed for only 27 days after fledging. Early fledged prairie falcons stayed in the nesting area for 3 weeks while the last fledged were gone within 2 weeks.

Irregardless of position in the nesting phenology most individuals of all migrant species of raptors had migrated from the area by mid-July and by mid-August all were gone. Townsend ground squirrels (a main prey species) began estivation in late May and by mid-July all were underground. We observed juvenile kestrels on the flats above the canyon in mid-August but adults were present all year.

The 1975 breeding season lasted 234 days beginning in early January with golden eagle courtship and ending in early September with juvenile eagle dispersal. While some young eagles were in or near the nesting area past that date we believe most were on their own and did not require care of their parents.

Reproductive Performance

The 1975 productivity of ravens and major raptors is presented in Tables 2 and 3. This data includes pairs located in 1973 and 1974 for all species except eagles, for which data since 1971 is used. Productivity was relatively high for all species except ferruginous hawks, which nevertheless experienced higher production than previous years.

Golden eagles: Of 60 identified sites in the Golden Eagle Study Area 58 were occupied in 1975. One which appeared traditional had not been observed in earlier years. Another formerly assumed to be one site was occupied by two breeding pairs. The "Pumping Station" site extends 1.4 miles (2.24 km) between the first and last alternate nest. However, two pairs nested at the extreme ends of the site 1.3 miles (2.1 km) apart this year. No nests were occupied or repaired at the adjacent "Waterfall" Site, 1.5 miles (2.4 km) from the west end of the Pumping Station Site, and it is possible this pair could have nested in one of the Pumping Station alternate nests. However, since we saw an adult eagle at the Waterfall Site we considered this Site and the two occupied nests in the Pumping Station Site as 3 separate occupied territories.

We collected productivity data (Table 2) from 57 pairs (one pair was located after fledging). Production (young per pair) has increased steadily since 1973 (0.40 to 0.52 to 0.65). Forty-one of 58 pairs (71%) laid eggs this year (Table 3): the greatest percentage since before the 1972 jackrabbit population crash. Fifteen pairs laid 32 eggs, hatched 23 and fledged 14 young or 43.8% of the eggs laid.

Prairie falcons: Average prairie falcon clutch size increase from 3.87 in 1974 to 4.40 in 1975. Average minimum brood also increased from 1974 to 1975 (3.18 to 3.88) as did average fledge per attempt (3.11

Table 2. Productivity of the major raptor species and ravens in the Study Area, 1975.

Species	Clutch No.	Clutch $\bar{x}$ (range)	Maximum brood No.	Maximum brood $\bar{x}$ (range)	Fledged/Attempt No.	Fledged/Attempt $\bar{x}$ (range)	Fledged/Pair No.	Fledged/Pair $\bar{x}$ (range)
Golden eagles	16	1.94 (1-2)	23	1.52 (0-2)	40	0.92 (0-2)	57	0.65 (0-2)
Prairie falcons	20	4.40 (2-5)	26	3.88 (0-5)	35	3.34 (0-5)	42	2.78 (0-5)
Red-tailed hawks	16	3.38 (1-5)	22	2.09 (0-5)	24	1.79 (0-5)	26	1.65 (0-5)
Ferruginous hawks		——— (——)	1	2.00 (——)	3	2.33 (0-5)	8	0.88 (0-5)
Great horned owls		——— (——)		——— (——)	6	2.33 (1-3)	13	1.07 (0-3)
Common ravens	12	5.08 (3-7)	15	3.30 (0-5)	35	2.80 (0-6)	43	2.45 (0-6)

Table 3. Breeding performance of the major raptor species and ravens in the Study Area, 1975.

Species	No. pairs	Nesting attempts	Attempts successful	% pairs breeding	Nest success (%) attempts	Nest success (%) pairs
Golden eagle	58	41	27	70.7	65.8	46.6
Prairie falcon	47	40	34	85.1	85.0	72.3
Red-tailed hawk	27	25	17	92.6	68.0	62.9
Ferruginous hawk	7	3	2	42.8	67.0	28.6
Common raven	45	41	32	91.1	78.0	71.1

to 3.34). Average clutch for 1975 was equal to that reported for this population in 1970-1972 (Ogden 1973), however, fledging per attempt was greater. Fledglings per pair 1975 was the same to that reported in 1974. This is possibly due to an increase in non-breeding. While this may have occurred 85% of the "pairs" bred in 1975 (Table 3). Of 47 sites observed only 1 was unoccupied; and it was last occupied in 1973. One site that was vacant in 1974 was reoccupied in 1975.

Twenty prairie falcon pairs laid 88 eggs, hatched 77 young and fledged 62 or 70% of the eggs laid. Most of the loss occurred during the pre-fledging period. We observed no re-nesting but it may have occurred with some of the late pairs we found.

Red-tailed hawks: Of 30 sites, 28 were occupied. Two sites vacant this year were occupied last year. Twenty-five pairs laid eggs, 2 pair failed to lay eggs and the reproductive status of one was uncertain, therefore breeding performance data was collected from 27 pairs (Table 3) and productivity from 26 (Table 2) (one pair was located after fledging). Clutch size was 11% higher than in 1974 and similar to 1973. Maximum brood size was down 22% from 1973 and 1974. Number fledged per attempt also was down but number fledge per pair was greater than 1973 or 1974.

Proportionally, more pairs of red-tailed hawks bred than any other species (Table 3). The percentage of breeding pairs greatly increased from 1974 to 1975 (69% to 93%). This increase may have been partially due to increased knowledge of the location of the breeding pairs. While a high percentage of pairs bred, overall breeding success was relatively low. This partially resulted from a fairly high loss of eggs (20%), which was due to many causes (Table 4). Seventeen red-tailed hawk pairs laid at least 56 eggs, hatched 45 and fledged 38 young (68% of eggs laid).

Ferruginous hawks: We located 8 traditional ferruginous hawk sites; 7 were occupied (Table 3). Three pairs attempted to breed while two pair fledged young, an average of 0.88 young per pair. One pair successfully fledged 5 young. Ferruginous hawks experienced the lowest breeding success of all species studied. However, breeding success in 1975 was greater than 1974 when only 1 brood fledged and in 1973 when no young fledged.

Great horned owl: Of 17 known sites, 1 was vacant and 3 were not checked for breeding performance. Six of 13 pairs studied fledged an average of 1.07 young which equaled last year's production.

We did not check great horned owl eyries for production until well after young had hatched to avoid disturbing other raptor species which were still incubating eggs. This, plus the inconspicuous nature of the nest, increased the possibility that unsuccessful

Table 4. Causes for raptor and raven egg and nestling losses in the Birds of Prey Study Area, 1975.

Species	EGGS					NESTLINGS						UNKNOWN
	Hatching failure	Missing	Abandoned	Predation	Wind	Disease	Predation	Heat prostration	Human activity	Other	Unknown	1.
Golden eagle	3	0	6	0	0	2[2]	0	2	1	1[3]	9	0
Prairie falcon	3	3	4	0	0	0	6	0	0	1[4]	7	1
Red-tailed hawk	1	4	1	3	2	0	3	3	3	2	4	0
Common raven	4	5	9	0	0	0	4	0	4	0	6	12
TOTALS	11	12	20	3	2	2	13	5	8	4	26	13

1. either unhatched egg or early nestling mortality
2. trichomoniasis
3. fecal compaction
4. egg was collected to determine cause

attempts or early nest failures were missed. Thus, non-breeding pairs of great horned owls were never observed. Considering only those sites where young were seen, numbers fledged per attempt averaged 2.33 young.

Common raven: Raven clutch and maximum brood size in 1975 was considerably lower than 1974. However, number of young fledged per attempt and per occupied site were comparable in both years. This resulted from an increase in breeding pairs in 1975 (85 to 91%), larger broods, and increased nestling survival. Of 51 identified sites, 49 were occupied in 1975. Breeding performance was collected from only 45. The two vacant sites were occupied in 1974. Eleven raven pairs laid 54 eggs, hatched 33 and fledged 29 young (54% of the eggs laid). Raven reproductive losses were the greatest during incubation with hatching failures and nest abandonment being the primary causes (Table 4).

Other raptors: We located one long-eared owl nest that contained at least two young, however all young were killed by an unknown predator before they fledged. One screech owl pair fledged four young while one barn owl pair fledged three.

Mortality Factors

Mortality causes for three major raptor species and ravens are presented in Table 4. Nest abandonment, missing eggs and hatching failures accounted for most egg losses while weather and predation accounted for few. Predation was the primary known nestling mortality cause. The only disease identified as a mortality factor was trichomoniasis or "frounce" diagnosed in two dead, seven week old eaglets. Trichomoniasis was diagnosed in two other birds that were successfully treated. Human activity consisted of shooting and human interference. The other category includes physiological malformations which may have been either disease caused or congenital disorders. The Unknown category includes losses where it was uncertain whether the eggs didn't hatch or nestlings died at a very young age. We found an unhatched raven egg 150 meters from an active nest that contained three young. Earlier the nest contained six eggs. It appears that ravens clean their nests of unhatched eggs making it difficult to assess embryonic mortality and maximum brood.

Banding and Marking

Species and numbers banded and color marked in 1975 are presented in Table 5. Sightings of color-marked birds within the Study Area provided data on dispersal patterns and dates, and is discussed in other sections of this report. To date we have received eight band returns or sightings of birds banded and color-marked in 1975.

Table 5. Species and numbers of raptors banded, wing marked, painted or wing marked and painted in the Snake River Birds of Prey Natural Area in 1975.

Species	No. Banded	No. color marked	No. painted	No. color marked and painted
Golden eagle	29	23	0	6
Prairie falcon	84	6	10	2
Red-tailed hawk	36	19	0	7
Ferruginous hawk	7	2	0	0
Great horned owl	4	0	0	0
Barn owl	2	0	0	0
Common raven	45	13	4	9
Totals	207	63	14	24

A color marked and painted juvenile eagle still had a small amount of paint on its tail when it was recovered in Nevada five months after painting. Painting was a very helpful technique in plotting individual movements of birds in the study area.

We experimentally placed wing markers on six prairie falcons this year. Young were watched until they dispersed from the study area. No apparent difficulty in the flying capability of the young birds was observed.

Sightings of golden eagles color-marked in 1970 and 1971 (Kochert 1972) continue to be reported. A bird color marked in 1971 was seen this field season on territory with an unmarked adult 15 miles (24 km) from its natal nest. There is a possiblity young hatched in this population return to their natal grounds to nest. Results of this and other sightings will be presented in subsequent reports and published papers.

Raptor Populations

The monthly tally from the raptor road transect is presented in Table 6. As in previous years the lowest raptor densities were observed in August, September, October and November. During this time the area is occupied by a few residents, transients and early wintering birds. December was characterized by an influx of wintering birds especially kestrels and golden eagles and to a lesser degree by American rough-legged hawks (Buteo lagopus) hereafter referred to as roughlegs.

Weather apparently influenced wintering activity of some species. The peak density of roughlegs in fall 1974 was at least a month later than in fall 1973. Furthermore, roughlegs were abundant at least one month later spring 1975 than that of 1974. Fall and early winter in 1974 was exceptionally mild while late winter and early spring 1975 was exceptionally cold and wet (U. S. Dept. Comm. Weather Bureau 1974-1975). Additionally, peak golden eagle wintering numbers for 1973-74 were seen in December and January; however, they did not peak until February in 1975.

The low number of birds seen in May and June was possibly due to the intense nesting activity of breeding birds requiring them to remain near nest sites. The variable numbers of ravens could be due to their gregarious nature combined with local movements of non-breeding birds.

The monthly raptor road transect shows seasonal fluctuations in the numbers of species and individuals of each species seen, but does not necessarily correlate to actual numbers present. Species such as the American kestrel, which utilized powerlines for hunting perches, may be represented far out of proportion to short-eared owls or marsh hawks, which seldom, if ever perch on powerlines and

Table 6. Monthly raptor road transects in the Birds of Prey Natural Area, 1975.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Golden eagle	3	9	3	6	8	11	1	4	2	1	1	10
Prairie falcon	5	7	11	7	1	1		1			1	1
Kestrel	8	4	6	5	8	1		5	12			10
Red-tailed hawk	7	4	4	4	2	1	3	1		1		1
Rough-legged hawk	12	11	7	12							3	3
Swainson's hawk				2	1	1				3		
Cooper's hawk		1	1									
Marsh hawk	4	3	2	2	1	1			1	1	2	2
Common raven	18	17	7	19	11	8			23	8	5	9
Shrike	1	1	1			2		3	4	2	1	4
Turkey vulture				2								
Short-eared owl						1						
Burrowing owl					1	4		1	3			
Barn owl		1										
Unknown Buteo		1		1	1					2		
Unknown falcon				1								
Unknown raptor							3					1
TOTAL	59	59	41	61	34	31	7*	15	45	18	13	41

* portion of tape erased.

therefore are less conspicuous. The September transect is much higher than the preceeding or following month due to an unusual number of ravens and kestrels seen.

Golden Eagle Population

The results of the pre- and mid-winter golden eagle aerial survey from 1972-1975 are presented in Table 7. There was a statistically significant decline (Kochert 1973) in eagle density from the fall-winter 1972-73 to the same period in 1973-74 (Fig. 5). While October eagle numbers declined slightly in subsequent years, the decline was not significant. Likewise the changes in eagle numbers in mid-winter from 1974-75 to 1975-76 were not statistically significant (t=0.9214).

Eagle numbers increase significantly from October to mid-winter each year (2.9 times in 1972-73, 2.4 in 1973-74, 2.0 in 1974-75 and 2.7 in 1975-76). These data indicate a large immigration of wintering golden eagles.

The adult:immature ratio significantly changed each year. In 1972-73 the ratio was approximately 50:50 which changed to 70:30 in 1973-74. The ratio remained relatively unchanged in 1974-75 (67:33) but then dropped to approximately 73:27 in 1975-76. The proportion of juveniles decreased the most between February 1973 and October 1973, which followed the nesting season in which eagle production was the lowest ever observed in this population.

Food Habits

Golden eagle: Food habits are presented in Table 8. Black-tailed jackrabbits and desert cottontails (Sylivagus natalli) comprised 67% of the biomass and 48% of the individuals. Townsend ground squirrels (Spermophilus townsendi) were taken in the same numbers as were cottontails but cottontails comprised 4 times as much biomass. Since the 1972 jackrabbit population crash, the proportion of jack-rabbits in the diet has remained relatively stable at 50%.

Ring-necked pheasants (Phasianus colchicus) were fourth in importance in terms of frequency of occurrence, but were next to jackrabbits in biomass. The proportion of pheasants in the eagle's diet decreased slightly from 1974 and was one-half of that observed in 1973. The male:female ratio of pheasants was 1:3.7 which is similar to the ratio observed in 1974, but differed from previous years with fewer hens reported than in 1973 (1:5.2) (Kochert 1973) and 1971 (1:5.8) (Kochert 1972). While jackrabbits and cottontails remained relatively stable (only a 1.2% increase in cottontails) the decrease in pheasants since 1973 was offset mainly by a 7 fold increase in snakes.

We compared prey found in nests located within intensively farmed areas, with those in moderately farmed areas, and those in range

Table 7. Golden eagle aerial transects, 7000 square miles Snake River flood plain, 1972-76.

Date	No. adults	No. immatures	Adult:Immature ratio	No. unknown	Total eagles	Other raptors*	No. coyotes	Eagles/100 mi^2 (256 km^2)
Oct 72	10	11	48:52	8	29	56	16	5.8
Feb 73	33	33	50:50	18	84	72	19	16.8
Oct 73	7	3	70:30	7	17	28	0	3.4
Jan 74	20	9	69:31	12	41	82	14	8.2
Oct 74	4	2	67:33	10	16	32	8	3.2
Feb 75	17	8	68:32	7	32	48	16	6.4
Oct 75	10	0	100:0	5	15	19	9	3.0
Jan 76	24	9	73:27	6	41	69	6	8.2

* includes bald eagles, red-tailed hawks, rough-legged hawks, ferruginous hawks, prairie falcons, American kestrels, marsh hawks, and unknown raptors.

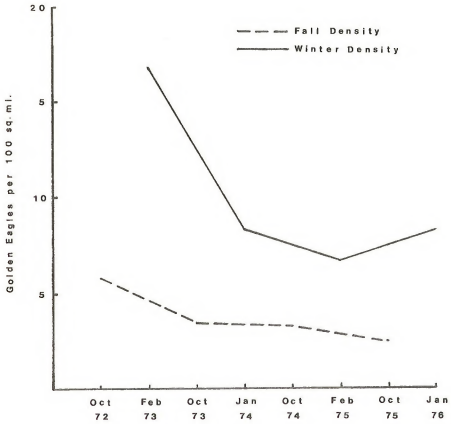


Figure 5. Fall and winter golden eagle density in the 7000 square mile Snake River flood plain, 1972-76.

Table 8. Golden eagle food habits in the Birds of Prey Study Area, 1975.

Species	Size Class	Sex	N	Percent (N)		Approx. Biomass (gm)	Percent Biomass	
	A	♂	1	0.3				
	A	♀	2	0.6				
Jackrabbit	A	Unk	35	10.7	(30.5)	80,180	26.95	54.95
	M	Unk	8	2.4		12,456	4.19	
	J	Unk	4	1.2		1,884	0.63	
	Unk		50	15.2		68,950	23.18	
	A	♂	2	0.6				
	A	Unk	23	7.0		20,675	6.95	
Cottontail	M	Unk	4	1.2	(17.4)	2,000	0.67	12.06
	J	Unk	4	1.2		860	0.29	
	Unk		24	7.3		12,336	4.15	
	A	♂	7	2.1		1,820	0.61	
	A	♀	2	0.6		374	0.13	2.23
Townsend	A	Unk	21	6.4	(17.7)	4,431	1.49	
gr. sq.	M	Unk	5	1.5		835	0.28	3.75
	Unk		23	7.0		3,703	1.24	
	A	Unk	3	0.9		9,000	3.03	
Marmot	Unk		3	0.9	(1.8)	5,001	1.68	4.71
	A	Unk	3	0.9		3,783	1.27	
Muskrat	Unk		6	1.8	(2.7)	6,939	2.33	3.60
Pocket gopher	A	Unk	1	0.3		240	0.08	
Microtus spp.	Unk		1	0.3		60	0.02	
Least chipmunk	Unk		1	0.3		78	0.03	
Woodrat	Unk		1	0.3		203	0.07	
Coyote	J	Unk	2	0.6		4,086	1.37	
TOTAL MAMMALS			236	72.0%		239,894	80.63%	
	A	♂	6	1.8		8,280	2.78	
	A	♀	21	6.4		21,357	7.18	10.77
Pheasant	A	Unk	2	0.6	(10.6)	2,398	0.81	
	M	Unk	1	0.3		883	0.30	12.90
	Unk		5	1.5		5,465	1.84	
Quail	A	♂	1	0.3		165	0.06	
Hun. partridge	Unk		1	0.3		376	0.13	
Rock dove	Unk		5	1.5		1,650	0.55	
Morning dove	Unk		1	0.3		113	0.04	
Starling	A	Unk	1	0.3		84	0.03	
Am. widgeon	A	Unk	1	0.3		709	0.24	
Pintail	A	♂	1	0.3		982	0.33	
G. W. teal	Unk		1	0.3		272	0.09	
Magpie	M	Unk	4	1.2		692	0.23	
	Unk		6	1.8		3,708	1.25	
Raven	J	♂	1	0.3		602	0.20	
Prairie falcon	J	Unk	2	0.6		1,430	0.48	

Table 8. cont

Species	Size Class	Sex	N	Percent (N)	Approx. Biomass (gm)	Percent Biomass
Red-tailed hawk	Unk		1	0.3	968	0.33
Am. Kestrel	Unk		2	0.6	218	0.07
Killdeer	A	Unk	1	0.3	106	0.04
Barn owl	A	Unk	1	0.3	321	0.11
Unk passerine	J	Unk	1	0.3	57	0.02
	Unk		1	0.3	57	0.02
Unk bird	A	Unk	1	0.3	195	0.07
TOTAL BIRDS			68	20.7%	51,088	17.17%
Gopher snake	M	Unk	1	0.3	372	0.13
	Unk		7	2.1	2,604	0.88
Rattlesnake	Unk		2	0.6	342	0.11
	A	Unk	1	0.3	372	0.13
Unk snake	J	Unk	1	0.3	91	0.03
	Unk		11	3.4	2,248	0.76
TOTAL SNAKES			23	7.0%	6,029	2.03%
Carp	A	Unk	1	0.3	500	0.17
TOTAL FISH			1	0.3%	500	0.17%
TOTAL			328	100.0%	297,511	100.00%

A = adult, M = medium, J = juvenile, Unk = unknown or average size

areas (Kochert 1973:22). As in previous years jackrabbits or cottontails were the most important prey in all strata (Fig. 6). Pheasants were most commonly found in nests located within intensively farmed areas, however we found pheasant remains in each of two golden eagle nests located in range areas. These nests were located within four miles of agricultural fields. Also, Jon Montan (Study IV a) has observed pheasants in range areas. Proportionally more Townsend ground squirrels were found in nests located in pure range areas than in nests in the other habitat types.

These data reveal a difference in prey captured in respect to proximity of agriculutural areas and the intensity of cultivation. If prey composition, density and availability is reflected in eagle predation then it appears there is a differential pattern of prey composition and density in relation to cultivation.

Prairie falcons: Food habits are presented in Table 9. As in previous years Townsend ground squirrels predominated in the diet in both biomass and number of individuals. Prairie falcons consumed almost entirely mammals (93% of the biomass).

This is the first year jackrabbits were observed in food habit collections. Three were juveniles, but two were adults. Sclater (1912) and Decker and Bowles (1930) in Bent (1961) both mention "hares", jackrabbits, and cottontails taken by breeding prairie falcons. We found 12 beetles in analyzed casts. Since they formed only a trace of the total biomass and they may have been stomach contents of a prey item, we eliminated them from the results. The two pocket gophers (Thomomys townsendi and T. spp.) were found in nests relatively close to irrigated pastures. One nest containing pocket gophers was located on the north side of the Snake River. The closest known population of pocket gophers was on the south side of the river 1½ miles from the nest, and the territory of at least one pair of falcons had to be crossed to reach this prey species.

Townsend ground squirrels predominated in the diet of three late broods (hatched in early June). However, one late nest contained 44% of all the lizards reported taken by prairie falcons. Townsend ground squirrels also predominated in the prey collections from our one sample nest located near agricultural fields. This indicates prairie falcons hunted native vegetation despite a prevalence of other habitat types.

We calculated the number of prey individuals found in 10 nests where we made intensive collections. The average minimum number of individuals consumed per day per nest ranged from 0.57 to 1.33 ($\bar{X} = 0.85 \pm 0.08$ se). We compared the average individuals consumed per day in three nests that contained two young, with five nests that contained five young and found no statistically significant difference ($t = 0.3884$). While these figures are minimum and are subjected to a certain degree of error they provide preliminary

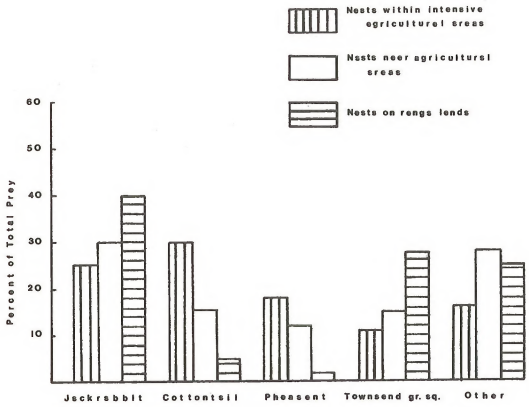


Figure 6. Frequency of major prey species found in golden eagle nests with respect to nest location and land use, 1975.

Table 9. Prairie falcon food habits in Birds of Prey Study Area, 1975.

Species	N	Percent (N)	Approx. Biomass (gm)	Biomass
Townsend gr. sq.	241	71.1	38,801	66.4
Jackrabbit	6	1.8	8,274	14.2
Cottontail	10	2.9	5,140	8.8
Kangaroo rat [1]	9	2.6	500	0.9
Deer mouse	4	1.2	68	0.1
Meadow vole	6	1.8	360	0.6
Woodrat	2	0.6	405	0.7
Pocket gopher[2]	2	0.6	410	0.7
Antelope squirrel	1	0.3	106	0.2
Unk. mouse	4	1.2	80	0.1
Unk. rodent	1	0.3	60	0.1
Unk fetus	1	0.3	60	0.1
TOTAL MAMMALS	287	84.7%	54,264	92.9%
Horned lark	2	0.6	56	0.1
Meadowlark	2	0.6	192	0.3
Red-winged blackbird	1	0.3	54	0.1
Raven	1	0.3	618	1.1
Valley quail	3	0.9	495	0.8
Chukar	1	0.3	571	1.0
Loggerhead shrike	2	0.6	104	0.2
Magpie	1	0.3	173	0.3
Morning dove	2	0.6	226	0.4
Canyon wren	2	0.6	20	T
Rock dove	1	0.3	330	0.6
Unk sparrow	1	0.3	17	T
Unk passerine	13	3.8	714	1.2
Unk bird	1	0.3	57	0.1
TOTAL BIRDS	33	9.7%	3,627	6.2%
Whiptail lizard	5	1.5	90	0.2
Horned lizard	1	0.3	24	T
Unk lizard	9	2.6	162	0.3
Unk snake	2	0.6	182	0.3
Spotted frog	1	0.3	60	0.1
TOTAL REPTILES AND AMPHIBIANS	18	5.3%	518	0.9%
Scorpion	1	0.3	2	T
TOTAL INVERTS.	1	0.3	2	T
TOTALS	339	100.0%	58,411	100.0%

1. Kangaroo rats were Dipodomys ordi and Dipodomys spp.
2. Pocket gophers were Thomomys townsendi and T. spp.

T trace

information on daily food consumption. Further refinement is needed and Study VII is directed towards this problem.

We analyzed prey remains from two prairie falcon eyries located in an area with a sparse population or that is void of ground squirrels (located between Glenns Ferry and Bliss, Idaho). More birds and less mammals were taken by these pairs than were taken in the intensive study area (birds, 43% vs 10% and mammals 52% vs 85%). Seven ground squirrels were identified in the remains. One nest was located five miles (8 km) from the known eastern edge of the Townsend ground squirrel population. The relationship of the other nest to ground squirrel populations is uncertain. Interestingly these two nests were of the four active sites located in a 30 mile stretch of canyon.

Red-tailed hawks: Food habits presented in Table 10 were collected from six nests evenly distributed between Halverson Lake upstream to Rabbit Springs. One nest was nearly surrounded by farming, two were near some farming and three were in pure range habitat.

As in previous years, Townsend ground squirrels predominated in both prey numbers and biomass. The percent biomass comprised by ground squirrels in the diet decreased 5% from 1974, but is 11% greater than in 1973. We identified more species of snakes in 1975 due mainly to help from Lowell Diller (Study IVa). Interestingly, we found six ground snakes (Sonota semiannulata) which supposedly are rare in the area. As in previous years, birds and lizards were not major prey items. This year was the first year we found jackrabbits in prey collections.

We calculated the average number of prey individuals captured per day in six intensively visited nests. The average number of individuals ranged from 0.7 to 2.3 ($\bar{X} = 1.3 \pm 0.2$ se). There was a large variance between nests which may have been influenced by differences in error and predation rates. However, this indicates a minimum count of individuals consumed per nest per day. The nest where 2.3 prey individuals per day were recorded had five eggs, indicating a superior food supply or skilled hunting techniques of the pair.

Prey composition and frequency in the nest near intensive farming differed little from that in the remaining nest. However, we found prey associated with farming areas (e.g. pheasant, starling (Sturnus vulgaris) and domestic cat (Felis domesticus) in this nest. In addition, observed prey frequency differences in nests in relation to their ordinal location. Downstream from Halverson Lake to Thomas Flats (three nests sampled) ground squirrels remained stable (67-54% of occurrence); however, at Wildhorse Butte the proportion of ground squirrels decreased to 37% and steadily decreased to Rabbit Springs (15%). We also observed a similar decline in the average daily number of prey individuals. Luttich et al. (1970) found that red-tailed hawks shifted their food habits proportionately to either abundance or

Table 10. Red-tailed hawk food habits in the Birds of Prey Natural Area, 1975.

Species (age, sex)	N	Percent (N)	Approx. Biomass (gm)	Percent Biomass
Townsend gr. sq. (A, ♂)	9	3.52	1,683.0	
(A, ♀)	11	4.30	2,860.0	
(A, unk)	16	6.25	3,376.0	
(Unk)	94	36.72	15,134.0	
(J, unk)	3	1.17	318.0	
Total Townsend gr. sq.	133	51.95	23,371.0	48.85
Jackrabbit (Unk)	4	1.56	5,516.0	11.53
Cottontail (Unk)	6	1.56	3,084.0	6.46
Kangaroo rat (Unk)	17	6.64	943.5	1.97
Deer mouse (Unk)	5	1.95	85.0	0.18
Meadow vole (Unk)	5	1.95	300.0	0.63
Woodrat (Unk)	3	1.17	609.0	1.27
Least chipmunk (Unk)	2	0.78	156.0	0.33
Long-tailed weasel (Unk)	1	0.39	178.0	0.37
Sorex spp. (Unk)	1	0.39	18.0	0.04
Marmot (Unk)	1	0.39	1,667.0	3.48
Domestic cat (Unk)	1	0.39	1,800.0	3.76
Muskrat (Unk)	1	0.39	1,158.0	2.42
Unknown mouse (Unk)	2	0.78	20.0	0.04
Unknown mammal (fetal)	1	0.39	60.0	0.13
TOTAL MAMMALS	183	71.48%	38,965.5	81.44%
American widgeon (M, ♂)	1	0.39	709.0	1.48
Pheasant (A, ♂)	1	0.39	1,380.0	2.88
Rock dove (Unk)	2	0.78	660.0	1.38
Morning dove (Unk)	1	0.39	113.0	0.24
Cliff swallow (A, unk)	1	0.39	15.0	0.03
Starling (Unk)	2	0.78	84.0	0.18
Meadowlark (Unk)	1	0.39	96.0	0.20
Red-winged blackbird (A, unk)	1	0.39	54.0	0.11
Unknown passerine	5	1.95	57.0	0.12
TOTAL BIRDS	15	5.85%	3,168.0	6.62%

Table 10. cont.

Species (age, sex)	N	Percent (N)	Approx. Biomass (gm)	Percent Biomass
Gopher snake (A, unk)	5	1.95	1,365.0	2.85
(Unk)	13	5.07	2,756.0	5.76
Striped racer (A, unk)	1	0.39	84.0	0.18
Ground snake (Unk)	6	2.34	46.8	0.10
Rattlesnake (Unk)	1	0.39	458.0	0.96
Unknown snake (Unk)	7	2.73	637.0	1.33
TOTAL SNAKE	33	12.89%	5,346.8	11.18%
Fence swift (A, unk)	1	0.39	17.0	0.04
Whiptail lizard (A, unk)	1	0.39	18.0	0.04
(Unk)	11	4.30	177.1	0.37
Leopard lizard (A, unk)	2	0.78	54.0	0.11
Uta lizard (Unk)	1	0.39	4.0	0.01
Unknown lizard (J, unk)	1	0.39	9.0	0.02
(Unk)	3	1.17	54.0	0.11
TOTAL LIZARDS	20	7.81	333.1	0.70
Unknown reptile (J, unk)	1	0.39	27.3	0.06
Total snake	33	12.89	5,346.8	11.18
Total lizard	20	7.81	333.1	0.69
TOTAL REPTILE	54	21.09%	5,707.2	11.93%
Beetle (Unk)	3	1.17	0.9	T
Scorpion (Unk)	1	0.39	1.5	T
Hymenoptera (Unk) *				
TOTAL INVERTEBRATES	4	1.56%	2.4	0.005%
TOTALS	256	99.98%	47,843.1	99.995%

A = adult, M = medium, J = juvenile, Unk = unknown or average.
* omitted from calculations
T trace

increase of available prey. If this applies to the BPNA, preliminary data indicate a difference in ground squirrel densities between the northwest one-half and the southeast one-half of the Natural Area.

Ravens: Townsend ground squirrels, as before, were the most important prey species in terms of numbers and biomass (Table 11). They were taken at a frequency similar to 1974. Biomass calculations for prey may be somewhat high because carrion was not tabulated in these calculations as we had no estimate of amount consumed. However, if we consider carrion, ravens consumed almost entirely mammals. Birds, fish, and reptiles formed little of the raven's diet. While insects formed a substantial proportion of the numbers they added very little to the biomass.

Ravens appeared to prey on small mammals and reptiles. We received 3 verified accounts of ravens killing Townsend ground squirrels (J. Doremus, J. Montan, and W. Melquist, pers. comm.). It appears, as a predator, ravens could be in direct competition with prairie falcons.

Great horned and barn owls: We collected castings from 5 great horned owl and 2 barn owl nests. The results of analysis have not yet been received. A report on these results will be forthcoming.

Time lapse movie analysis: With the assistance of personnel of Study VII we photographed the feeding visits at one prairie falcon eyrie. We used 8 rolls of Super 8 movie film or 28,800 frames. We also used a total of 13 rolls (54,000 frames) at a red-tailed hawk and golden eagle eyries. Full analysis of the film is pending acquisition of the proper movie film analyzer. A report on these results is forthcoming.

Organochlorine and Heavy Metals

Levels of organochlorine residues in red-tailed hawk and prairie falcon eggs collected in 1974 and 1975 (Table 12) were low when compared to levels in highly contaminated raptorial and fish eating birds (Risebrough et al. 1970). Prairie falcon eggs contained the highest levels while the levels in red-tailed hawk eggs closely resembled those found in golden eagle eggs from this area in 1970 and 1971 (Kochert 1972). Dieldrin levels in prairie falcon eggs were lower than those causing reproductive failure (Enderson and Berger 1970). DDE levels were considerably higher in prairie falcons than red-tailed hawks or golden eagles (Kochert 1972).

Total mercury level in the eggs and tissue of golden eagles, prairie falcons, red-tailed hawks, ravens, pheasants and rock doves are presented in Table 13. Red-tailed hawk, prairie falcon, and raven samples and golden eagle eggs were collected in 1974 and 1975. The eagle feather, pheasant and rock dove samples were collected in 1973. Levels were below those causing death and physiological malfunctions

Table 11. Raven food habits in the Snake River Birds of Prey Study Area, 1975.

Species	N	Percent (N)	Approx. Biomass (gm)	Percent Biomass
Cottontail	1	.3	500	1.1
Townsend gr. sq.	256	75.7	43,520	92.6
Pocket gopher	4	1.2	900	1.9
Kangaroo rat	1	.3	62	.1
Deer mouse	2	.6	34	.1
Harvest mouse	2	.6	30	.1
Meadow vole	2	.6	110	.2
Woodrat	4	1.2	812	1.7
Unk. mouse	1	.3	16	T
Unk. rodent	1	.3	15	T
TOTAL MAMMALS	274	81.1%	45,999	97.8%
Meadowlark	1	.3	96	.2
TOTAL BIRDS	1	.3%	96	.2%
Horned lizard	2	.6	35	.1
Uta lizard	1	.3	4	T
Unk. lizard	1	.3	18	T
Unk. snake	1	.3	372	.8
TOTAL REPTILES	5	1.5%	429	.9
Unk. fish	2	.6	454	1.0
TOTAL FISH	2	.6%	454	1.0
Beetle	32	9.5	9.6	T
Scorpion	21	6.2	30.5	.1
Grasshopper	2	.6	1.3	T
Wasp	1	.3	.2	T
TOTAL INSECT	56	16.6%	41.6	.1
Carrion				
Cow	*			
Coyote	*			
Marmot	*			
Vegetable				
Melon seeds	*			
Cereal Grain	*			
TOTAL	338	100.1%	47,019.6	100%

T trace
* amounts not calculated

Table 12. Organochlorine levels in prairie falcon and red-tailed eggs, Snake River Birds of Prey Natural Area, 1974-75.

Species	Tissue	N	Average ppm. Wet Weight (range) Heptachlor epoxide	DDE	DDT	DDD	B-BHC	Dieldrin
Prairie falcon	egg	10	0.154 (nd-0.762)	1.934 (0.273-5.114)	0.009 (nd-0.051)	T (nd-0.011)	T (nd-0.003)	0.132 (nd-0.473)
Red-tailed hawk	egg	3	0.021 (0.010-0.003)	0.783 (0.377-1.374)	0.007 (nd-0.037)	---	---	0.040 (0.034-0.046)

T trace
nd none detected

Table 13. Total mercury residues in eggs and tissue of some major raptors, ravens and prey species in and near the Snake River Birds of Prey Natural Area, 1973-75.

Species	Tissue	Number	ppm Hg^{+} ($\bar{x} \pm se$)
Prairie falcon	egg	10	0.046 ± 0.042
Golden eagle	egg	2	0.018 ± 0.001
Golden eagle	feather	12	0.246 ± 0.125
Red-tailed hawk	egg	3	0.021 ± 0.018
Raven	egg	1	0.060
Ring-necked pheasant	muscle	6	0.026 ± 0.026
Rock dove	muscle	1	0.005

in raptors (Fimreite and Karstead 1971 and Borg et al. 1969) or those from birds in highly contaminated areas (Fimreite et al. 1970). Prairie falcon eggs contained not only the highest organochlorine levels but the highest mercury levels as well. One raven egg contained 0.06 ppm but 4 prairie falcon eggs equaled or exceeded this amount.

The mercury levels in the 2 golden eagle eggs were similar to those found in 1970 and 71 (Kochert 1972). No significant decrease was seen between levels in samples of 12 feathers taken from fledglings in 1973 and those found in feather samples taken from the same age class in this population in 1971 (Kochert 1972). However, a significant decrease in levels in muscle of pheasants found in eagle nests was seen between 1971 (Ibid) and 1973.

Jackrabbit - Golden Eagle Relationships

The relationship between golden eagle production (young fledged per pair) and the previous fall jackrabbit index (Fig. 7) reveals a convincing correlation ($r = 0.79$) which resembles a straight line. Jackrabbit indices for fall 1970 and 1971 are from the Curlew Valley on the Utah-Idaho border (Stoddard unpubl.). For the last few years the jackrabbit index for our study area and the Curlew Study Area have been nearly identical. Therefore, we feel the use of the curlew data for comparison purposes is valid.

The decreased golden eagle reproductive performance since the 1972 jackrabbit crash has been influenced by a decrease in: 1) clutch size (no 3 egg clutches have been observed since 1971), and 2) decrease in the number of breeding pair (however, the number of occupied sites remained relatively stable).

This decrease in reproductive performance has been reflected in the wintering golden eagle population. Eagle wintering density decreased 50% between fall 1972 and fall 1973 and has since stabilized while the immature portion of the population decreased from 50% to 27%.

It is apparent from the data presented there is a strong relationship between golden eagles and jackrabbits. The data indicates the reaction of golden eagles to a reduction of their major prey is non-breeding and decreased reproductive performance. More description and discussion on golden eagle - jackrabbit relationships will be presented in a forthcoming paper.

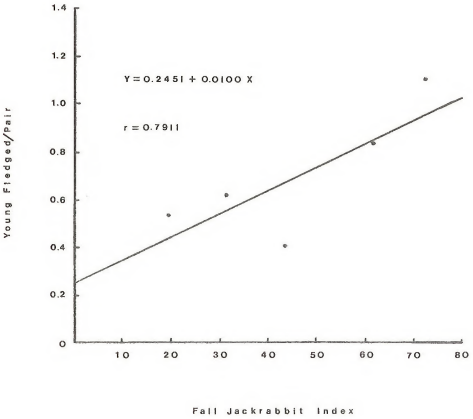


Figure 7. Correlation between fall jackrabbit numbers and golden eagle reproduction the following spring, 1970-75.

DISCUSSION

The nesting density in the intensive study area is the greatest ever reported for such a large area. However, differences in nesting density within this population occur, especially with prairie falcons. The greatest nesting density lies between Halverson Lake and Swan Falls; upstream to Grand View the population density decreases. As reported by Ratcliffe (1962) we observed a greater nesting density in the areas of higher cliffs. However, the effect of prey availability upon nesting density is uncertain. We observed differential food consumption with red-tailed hawks between Halverson Lake and Grand View, indicating decreased availability of ground squirrels in the southeast end of the area. The phenomena needs further investigation.

The unusually high population of prairie falcons only extends from Guffey Butte to Indian Cove Bridge (approximately 60 miles of river). In this area 165 prairie falcon, 26 golden eagle and 46 red-tailed hawk pairs were counted. Considering prairie falcons, we counted only 2 pairs in a stretch of the canyon 14 miles downstream from Guffey Butte and only 4 active pairs were located in a 36 mile section upstream from the Indian Cove Bridge. In both cases the cliff was apparently comparable to that within the intensive study area.

If the distribution of this phenomenal nesting population of ravens and raptors is compared with the spacial distribution of ground squirrels (S. townsendi, idahoensis) we find a high correlation. Also, if we compare the breeding phenology of prairie falcons in this area with the phenology of the ground squirrels (See Study V) we again find a high correlation. These similarities in conjunction with the dependence of prairie falcons, red-tailed hawks and ravens upon ground squirrels for food indicates the need to manage ground squirrel habitat to maintain raptor numbers. The two areas surveyed upstream and downstream of this phenomenal area contained either a sparse population or no ground squirrels.

There is a strong indication that juvenile dispersal is linked to food availability. As mentioned earlier we observed that in species depending on ground squirrels, juveniles fledging earlier have a longer post fledging period than those fledging later. We, as other project team members observed, prairie falcon dispersal was temporarily correlated to ground squirrel estivation.

This juvenile dispersal period appears to be critical with prairie falcons. During the post fledging period T. Dunstan (Study III) and G. Sitter (Study VII) reported 5 dead, missing or starved juvenile prairie falcons along a 2 mile stretch on the north rim of the Snake River Canyon. One bird disappeared only a few days after fledging and is assumed to have died; another bird was found nearly dead from starvation on the canyon floor; the others were found dead. Assuming these birds came from only the north rim (2 were known to come from there), in a section where 23 young fledged (8 pairs times the mean

young per pair), 22% of the prairie falcons fledging died before dispersal. If this is correct, the high mortality during this period may be caused by inexperienced hunting techniques and ground squirrels going into estivation. The matter will be investigated further by personnel from Study III and VII.

Preliminary results with management implications are beginning to emerge from these studies. Ground squirrels have been the predominant prey species of the major raptor species and ravens in the study area; lagomorphs have been extremely important prey for golden eagles and are important to buteos. However, prime habitat for jackrabbits and ground squirrels may not necessarily be the same. Jackrabbit numbers are greatest in big sage areas (Study IVa while ground squirrels appear to be more numerous in low vegetation that has been disturbed (Study V). If a management effort was directed entirely toward the enhancement of ground squirrel habitat it could decrease the quality of jackrabbit habitat thus having an effect on the golden eagles.

In 1975 the raptor and raven populations in the study area nested at a density hihger than any previously reported and their reproductive performance indicated a healthy environment. Organochlorine and mercury levels were low.

Differences in food habits within certain species of raptors show a response to variations in prey populations and habitat types and is providing basic information on effects of past habitat alteration upon raptor numbers.

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Appendix 1. Weight of prey items found in raptor nests, Snake River Birds of Prey Study Area, 1975

Species	Approximate weight, grams: Adult (Large)	Immature (Medium)	Baby (Small)	Unknown (Average)	Source
MAMMALS					
Black-tailed jackrabbit (Lepus californicus)	2110	1557	471	1379	Stoddard (Pers. Comm.)
Mountain cottontail (Sylvilagus nuttalli)	827	500	215	514	This Study, Montan (1975)
Townsend ground squirrel (Spermophilus townsendi)					
male	260				
female	187				
unk.	211	167	106	161	Melquist (1975)
Whitetail antelope squirrel (Ammospermophilus leucurus)	106				Hall (1946)
Least chipmunk (Eutamius minimus)	78				Smith & Murphy (1973)
Yellowbelly marmot (Marmota flaviventris)	3000	1500	500	1667	Hall (1946)
Townsend pocket gopher (Thomomys townsendi	240				Hall (1946)
Valley pocket gopher (T. bottae)	170				Smith & Murphy (1973

Species	Adult (Large)	Immature (Medium)	Baby (Small)	Unknown (Average)	Source
Great Basin pocket mouse (*Perognathus parvus*)	15				Smith & Murphy (1973)
Kangaroo rat (*Dipodomys* spp.)	55.5				Hall (1946)
Deer mouse (*Peromyscus maniculatus*)	17				Smith & Murphy (1973)
Meadow mouse (*Microtus* spp.)	60				Porter & White (1973)
Bushy-tailed wood rat (*Neotoma cinerea*)				287	Montan (1975)
Desert woodrat (*Neotoma lepida*)				118	Montan (1975)
Unknown woodrat (*Neotoma* spp.)				203	This Study
Muskrat (*Odontra zibethica*	1261	1052		1157	Donohoe (1966)
Unknown mouse (Unknown)				20	This Study
Unknown shrew (*Sorex* spp.)				18	This Study
Domestic cat (*Felis domesticus*)				1800	This Study
Long-tailed weasel (*Mustela frenata*)	178				Smith Murphy (1973)
Coyote (*Canis latrans*)			2043		This Study

Species	Adult (Large)	Immature (Medium)	Baby (Small)	Unknown (Average)	Source
BIRDS					
Hungarian partridge (*Perdix perdix*)	376				McGahan (1966)
Ring-necked pheasant (*Phasianus colchicus*)					
male	1380				
female	1017				Montan
unk.	1199	883		1093	(1975)
Chukar (*Alectoris graeca*)				571	Christ-ensen (1970)
Common Raven (*Corvus corax*)		618			This Study
Black-billed magpie (*Pica pica*)	173				Smith & Murphy (1973)
Rock dove (*Columba livia*)	330				This Study
Red-winged black-bird (*Agelaius phoeni-ceus*)	54				Porter & White (1973)
Western meadowlark (*Sturnella neglecta*)	96				Montan (1975)
Horned lark (*Eremophila alpestris*)	28				Montan (1975)
Loggerhead shrike (*Lanius ludovi-ianus*				52	Esten (1931)
Unknown teal (*Anas* spp.)				250	This Study

Species	Adult (Large)	Immature (Medium)	Baby (Small)	Unknown (Average)	Source
Pintail (Anas acuta)				982	Bellrose (1976)
Killdeer (Charadrius vociferus)				106	Porter & White (1973)
Mourning dove (Zenaidura macroura)				113	Balph (1973)
Unknown sparrow (Unknown)				17	Balph (1973)
Prairie falcon (Falco mexicanus)				715	This Study
Red-tailed hawk (Buteo jamaicensis)				968	This Study
REPTILES					
Side-blotched lizard (Uta stansburiana)				3.6	Diller (1975)
Western fence lizard (Sceloporus occidentalis	16.9			15.3	Diller (1975)
Desert horned lizard (Phrynosoma platyrhinos)	24.3			17.3	Diller (1975)
Western whiptail lizard (Cnemidophorus tigris	17.9			16.1	Diller (1975)
Leopard lizard (Crotaphytus wislizenii)	26.6			23.2	Diller (1975)
Unknown lizard (Unknown)				18	Diller (1975)

Species	Adult (Large)	Immature (Medium)	Baby (Small)	Unknown (Average)	Source
Gopher snake (Pituophis melano-leucus	273			212	Diller (1975)
Western rattlesnake (Crotalus viridis)	478	105		458	Diller (1975)
Ground snake (Sonota semiannulata)				7.8	Diller unpubl.
Long-nosed snake (Rhinocheilus lecontei)				9.0	Diller unpubl.
Striped racer (Masticophis taenia-tus)	84			77	Diller (1975)
Unknown snake (Unknown)				91	Diller unpubl.
FISH					
Carp (Cyprinus carpio)				500	This Study
INVERTEBRATES					
Grasshopper (Locustidae)				0.63	Smith & Murphy (1973)
Scarab beetle (Scarabidae)				0.30	Smith & Murphy (1973)
Scorpion (Scorpionidae)				1.45	Smith & Murphy (1973)

ANNUAL REPORT 1975

Study III: Activity, hunting patterns, territoriality, and social interactions of birds of prey in the birds of prey natural area.

Contractor: Western Illinois University

Investigators: Thomas C. Dunstan Principal Investigator

James F. Harper Natural Science Technical Assistant

Project Support: U.S. Department of the Interior, Bureau of Land Management Contract No. 52500-CT5-1013.

Objectives:

1. To determine the space needed by breeding golden eagles, prairie falcons, and red-tailed hawks for food gathering within and outside of the Birds of Prey Natural Area.

2. To determine the daily activity rhythms of each of the species and to ascertain the interrelationships between the three species.

3. To determine the fledging and dispersal activities of the young of the three species.

4. To coordinate the above mentioned objectives with the objectives of investigators studying the ecology of the prey species of the three species of raptors previously mentioned.

Annual Summary:

The habitat use and behavior of golden eagles at 2 nest sites, of red-tailed hawks at one nest site, and prairie falcons at 5 nest sites were studied between 1 January and 31 December, 1975 as part of a three-year study. Radio transmitters were placed on 2 young golden eagles, 1 adult male and 2 young red-tailed hawks, and 2 female and one male adult prairie falcons and their 7 young in order to facilitate following adults on feeding flights and young on dispersal flights. General behavior, home range sizes, habitat use, and dispersal was determined for the radio tagged subjects. Additional data was gathered at 3 other prairie falcon nests.

Plans for Nest Season:

Adult golden eagles, red-tailed hawks, and prairie falcons and young of each species will be tagged with radio transmitters in order to complement the 1975 data. Study subjects will be located at nests from Halverson Lake to Grandview and again in the Intensive Study Area. Emphasis will be placed on determining horizontal land use by each species and dispersal of the young.

METHODS

The office and laboratory: The Principal Investigator established a residence in Boise, Idaho in December, 1974 and organized an office and laboratory during January, 1975. The office/laboratory contains a library of scientific reprints, reports, and texts to be used as reference material for Study III. Materials are divided into sections on ornithology, radio telemetry, pesticide and heavy metals, game management, basic ecology techniques, and recent copies of appropriate scientific journals. A map library includes maps of the study area, local counties, the state of Idaho, regional mountain ranges, weather patterns, and the western states. A mapping wall board was established for plotting data used in discussions and data analysis. One area of the office/laboratory has been designed for building radio telemetry equipment, storing and charging batteries, testing transmitter components, and designing and building related project equipment. Another area of the office/laboratory is used for embedding transmitters and allows for the use of noxious chemicals. Photographic slides and prints are analyzed and stored in the office and equipment for viewing slides and making maps is also present. Live traps are built in the office/laboratory and stored in an outbuilding along with the receiving antennas and automobile mounts. Lure animals are stored in the office/laboratory during harsh weather and in the outbuilding or at the residence of the Technical Assistant during the trapping season.

Building of equipment:

Radio transmitters and packages: Radio transmitters and packages were custom built to suit each sex and species of bird studied because of the species-specific tolerance to marking with radio packages. Because of the difference in morphology and behavior between species we found it necessary to redesign and modify our previously published package types to suit our exact needs. Radio packages for prairie falcons (Falco mexicanus) were of two different designs. The basic back package harness of Dunstan (1972) was used to hold a transmitter with a 22.9 cm (9 inch) whip antenna for the male, and a 30.5 cm (12 inch) whip antenna for the female on the bird's back (Fig. 1). A .6 mm (¼ inch) woven teflon ribbon type 8476 (Bally Ribbon Mills) was used as the harness strap. The transmitters were powered by 1.5 volt Mallory Model 660 mercury batteries and the total package weight was 18 and 20 g (Table 1). Female and male red-tailed hawks (Buteo jamaicensis) were tagged with the same type of back package, however, the transmitter was powered by 1.5 volt Mallory 828 mercury batteries and the total package weight was 24 g. The golden eagles (Aquila chrysaetos) were tagged with back packages that featured a back package harness as previously described placed inside of a sack made of yellow Fabric-ATV-16 (Cooley Inc.) as shown in Figure 1. The transmitters were powered by 1.5 volt Mallory ZM 12 mercury batteries or Eternacell 2.8 volt Model 660-2 or 660-3 Lithium batteries. Total package weights were 40 and

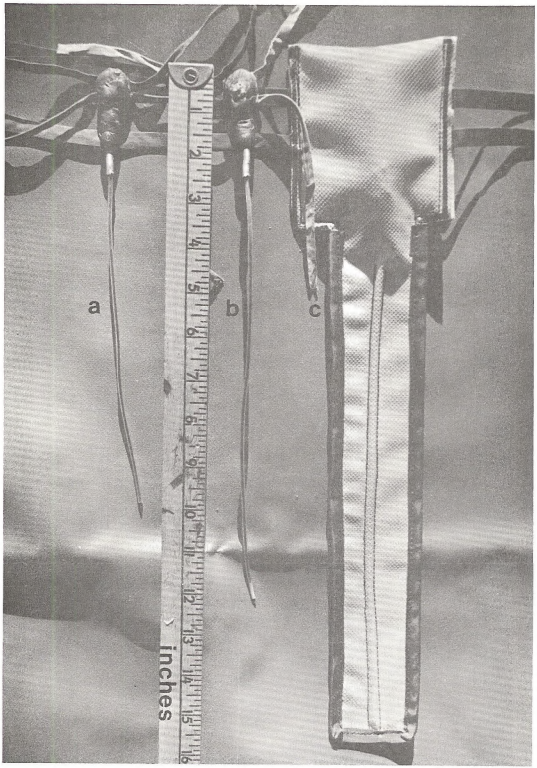

Figure 1. Three types of radio transmitter packages used to tag study subjects. From left to right, package used on a male prairie falcon (a), a female prairie falcon (b), and golden eagles (c).

Table 1. Data about 15 radio tagged study subjects marked in the 1975 breeding season.

Nest site	Bird no.	Date tagged	Age	Sex	Weight (g)	Foot pad size (mm)	Radio type	Number of leg band	Additional markers
PF-1	PF-1	21 April	Ad.	F	881	89.4	18 g pack	987-16301	
		9 June*			869				
	PF-4	1 June	Yg.	U	864	94.3	20 g pack	987-16337	rt..primaries yellow paint
	PF-5	1 June	Yg.	U	801	94.0	20 g pack	987-16338	rt. primaries yellow paint
	PF-6	1 June	Yg.	U	894	93.0	20 g pack	987-16339	rt. primaries yellow paint
PF-2	PF-2	29 April	Ad.	F	913	87.9	20 g pack	987-16302	
		14 May*							
	PF-3	16 May	Ad.	M	529	77.0	18 g pack	836-77001	
	PF-7	14 June	Yg.	U	500	75.5	18 g pack	836-77021	left primar. yellow paint
	PF-8	14 June	Yg.	U	753	88.2	18 g pack	987-16351	left primar. yellow paint
	PF-9	14 June	Yg.	U	795	91.9	18 g pack	987-16352	left primar. yellow paint
	PF-10	14 June	Yg.	U	544	78.5	18 g pack	836-77022	left primar. yellow paint
RT-1	RT-1	29 May	Ad.	M	-	83.3	24 g pack	987-16303	yellow right wing tag
	RT-2	6 June	Yg.	U	866	86.7	24 g pack	877-37811	yellow right wing tag
	RT-3	6 June	Yg.	U	870	83.4	24 g pack	877-37812	yellow right wing tag
GE-1	GE-1	15 June	Yg.	M	3,450	134.3	40 g sack yellow	599-11928	yellow left wing tag
	GE-2	15 June	Yg.	M	3,150	133.0	60 g sack yellow	599-11929	yellow left wing tag
		23 Sept*			3,620				

* recaptured and retagged bird.

60 grams. The purposes of using this "back sack" type of harness were to minimize antenna breakage and to provide a long-lasting color marker for use after the battery power failed. The transmitters for the falcons and hawks were single stage (one transistor) units and two eagle transmitters were two-stage (2 transistors) units modified after the circuitry of Cochran (1967). A third eagle transmitter (single stage) was built in our laboratory. In addition to the whip antenna that trailed down the bird's back, a ground plane antenna was passed from the positive lead of the battery through the teflon tubular body strap of the harness enabling additional signal strength.

Components for the single state transmitters were tested for compatability (in the circuits) and only superior components were used in transmitter construction. Transmitters were built for specific purposes of life and power depending on the bird tagged. Two-stage transmitters were purchased from AVM Instrument Co. and built into custom made packages in our laboratory. A total of 23 crystal controlled 220 MHz transmitters with pulsed signals were constructed from superior parts of the 78 transistors, 100 capacitors, 250 resistors, and 40 crystals tested. Seventeen superior transmitters were used in constructing single stage packages for study subjects. In addition, 3 other transmitters were built for field and lab tests and 3 transmitters of inferior quality were used for markers in the field.

The tracking vehicle: An International Travelall with 4-wheel drive was modified for use in tracking and monitoring birds marked with radio transmitter packages (Fig. 2A). A 2-inch O.D. steel pipe was passed through the middle of the roof behind the front seat and mounted so that the pipe could be turned 360 degrees by use of a handle through the pipe from inside the cab (Fig. 2B). An indicator needle was mounted on the pipe and used to indicate the direction of the receiving antennas as related to the orientation of a compass card mounted on the roof inside of the vehicle. Two 220 MHz 11-element yagi receiving antennas were mounted one-half and one m above the roof of the vehicle on the pipe. One antenna was mounted for vertical polarity and the other for horizontal polarity. Two 220 MHz 5-element yagi antennas were mounted for vertical polarity parallel to the 11-element antennas and at opposite ends of a 1½ m boom mounted to the pipe ½ m above the roof of the vehicle (Fig. 2A). The five-element antennas were wired for null-peak operation and the 11-element antennas were wired for peak signal only. Coaxial lead-in wires were passed through the pipe and into the cab and were attached to one or two Model LA 12 Tracking Receivers (AVM Instrument Co.) and to appropriate null-peak switch boxes and connectors (Fig. 2B). Receivers were connected to allow monitoring of two different radio marked subjects simultaneously by either one or two receiver operators. The receivers were wired and powered by internal or external power sources. The vehicle and receiving equipment worked well probably because of regular inspection and maintenance. For most of the ground tracking, the 11-element antenna in horizontal plane worked well and the two 5-element null-peak antennas

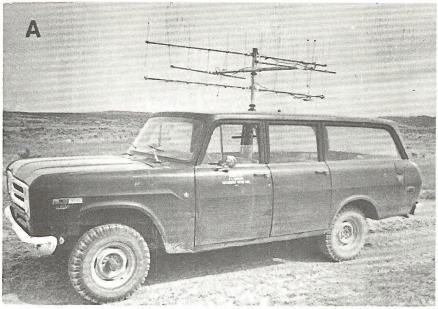

Figure 2. (A) The radio tracking vehicle with vertical and horizontally polarized yagi antennas. (B) Tracking receivers and turning pipe.

proved unnecessary for use in our 1975 studies. The vehicle was serviced every 1,600 km (every 8-10 days) and some field days were lost during these maintenance periods, more during the detailed 19,000 km inspections.

Receiver equipped aircraft: During the dispersal phase of the study and also when checking the entire Bird of Prey Natural Area (hereafter B.P.N.A.) for radio marked birds, receivers and antennas were installed on fixed wing aircraft. Antennas were placed on both wing struts and directed forward or at right angles from the body of the airplane depending on the type of search. Cessna 150 (2 seats), 172 (4 seats) and 182 (4 seats) airplanes with cruising speeds of 160, 192, and 224 kmph respectively, were used depending on availability and terrain to be flown. The five-element antennas were attached to the wing struts using large sponges for support at the point of contact and were tied on with nylon parachute cord and knots were secured with tape. A welded aluminim strut mount was also used on occasion and is pending FAA approval. During most flights, two antennas were placed perpendicular to the fuselage, with the elements in vertical polarization, and the boom of each antenna directed down 30 degrees from the wing. The coaxial cable from the antennas to the receiver passed through the cabin air intake and connected to the receiver by a "T" connector. Eight-ohm headphones were used to keep out ambient noise. Proper equipment function was checked when the airplane was airborn using a test transmitter before a search was begun. The reception range varied with the relative positions of the receiving and transmitting antennas. At times one would expect a reception of 20 to 60 km, however, we relied on the reception for transmitters positioned as to give minimum signal range during our searches. The reliable minimum reception for single stage units positioned almost flat on the ground as would be the case for a dead bird was 2½ to 3½ km and for the two stage units 5 to 8 km from an airplane flying at 1,000 to 2,000 m above the terrain. In general, the receiving equipment functions on a line-of-sight plane and birds behind obstacles or in crevices of the canyon wall would be difficult to locate. There are no written rules that can replace experience with the equipment and tracking procedures.

Tracking and monitoring procedures: During most of the study the marked birds were followed and monitored from the ground vehicle. Major emphasis was placed on following the adult birds during their hunting flights out across the desert. The vehicle was positioned at locations between the nests and expected hunting areas, and birds either coming out from or going back to the nests were intercepted and followed at various distances depending on the bird's flight speed and the location and condition of the automobile trails through the desert. For most of the trips, previously made trails were used and desert vegetation was not overrun. Flying birds were sometimes seen if they were within 1.6 km of the vehicle and signals could be heard up to 7 km from a vehicle positioned on the high buttes in the study area. Experience

gathered in years past allowed for exact locations or locations within 1 km of actual position. Simultaneous plotting of locations by the vehicle personnel and persons on foot with receivers allowed for position checks and exact locations. Persons making simultaneous plottings when positioned up to 8 km apart kept in contact with Citizen Band (CB) radios. Similar procedures were used to determine if birds returning to the nests carried prey back from hunting areas when the ground vehicle person watched the hunting and a second observor stationed at the rim of the canyon above the nest tracked an incoming bird and checked for captured prey. A 2-channel Rustrak Event Recorder (Gulton Industries Inc) and 2 telemetry receivers were also located near the nest and monitored the presence or absence of tagged adults when personnel were involved in tracking away from the nest area. This recording system was experimental and did show promise for use during the 1976 season.

The procedure for tracking from an airplane was to fly from the airport at Boise and pass over the desert to the B.P.N.A. during which time the receivers were tuned to find a missing bird. The flight paths continued to the vicinity of the nest of the missing bird and circled the general area crossing the canyon after which the airplane took a course either east or west parallel to the river. Flights went as far west as Marsing, Idaho, out of the B.P.N.A., south to the foothills of the Owyhee Mountains, east to the Grandview and C.J. Strike Reservoir area and north to the Sawtooth Mountain Range by Boise. The object of the aerial searches was to either relocate the marked bird and continue tracking during dispersal or to make sure that the bird had left the B.P.N.A.. During the flights the airplane was flown at from 1,000 to 2,000 m and steered in a gentle rolling zig-zag pattern to check ahead and behind and to change the angle of the antennas with respect to the ground as the wings banked. Once a signal was received, one of the two antenna connectors was disconnected from the receiver and the plane maneuvered in a tight circle to determine the approximate azimuth of the loudest signal. By continuing the circle flights, reducing the gain of the receiver, and flying lower, the bird was located to within 500 m and close enough to be found by the ground vehicle if the transmitter remained stationary. Most aerial searches were conducted during the falcon dispersal period in July, and during August for the hawks. Eagle searches were conducted as the birds began to range farther than 6 km from the nests. Although missing birds could not always be located, the searches did prove their absence from the B.P.N.A.. We believe that transmitter failure was not a factor in our 1975 work during the dispersal period because the pulse rates of all units were timed daily and symptoms of malfunction watched closely.

Trapping equipment: Prior to and during the breeding season various trapping devices were constructed and tested. Eight bal-chatri traps (Berger and Hamerstrom, 1962) were constructed for use in trapping falcons and hawks. Four dho-gazza nets measuring 1½ by 1½ m and 7 noose carpets of irregular small shapes (approx. 10 by 15 cm) and fitted with 40 lb. test monofilament line were made for capturing falcons and hawks (Beebe

and Webster, 1964). An experimental remote controlled bownet and electric lure were designed for use in trapping all species. A stuffed Townsend ground squirrel (Spermophilus townsendi) was mounted in an upright position on a battery powered table that rotated at 5 rpm. The electric lure was placed by dho-gazza nets and by the bownet so that only the moving squirrel appeared above the soil (Fig. 3). Two remote controlled bownets, one for use in trapping eagles, hawks, and falcons and one for hawks and falcons, were constructed (Fig. 3). The bow was made from 1.2 cm O.D. seamless alluminum pipe with .12 cm walls. The bows were powered by coiled springs attached to the bow by adjustable hoseclamps. The netting covering the bows was of heavy 1.2 cm nylon. The triggering system was composed of a 2-channel radio transmitter that transmitted a signal in the 72 MHz frequency range to a small receiver that in turn activated a small motor (servo) that released a mouse trap-like latch that held the cocked bows together (Fig. 3). The bownet could be released at a distance of 1.6 km if needed. Although the electronic bownet and lure was not used extensively in 1975 it should prove useful in 1976.

Population census: Population censuses were conducted to enable us to become familiar with the species in and adjacent to the B.P.N.A. and to detect population fluctuations during the year. Pole Censuses were conducted from January through April,1975, to sample raptor winter population sizes and fluctuations in the designated Intensive Study Area and adjacent to the B.P.N.A.. The pole census was run along the tall powerline and the short-poled powerline poles numbered 217 to 268 and 7 through 78 (north and south sides of Swan Falls road) respectively. The route was run 11 times and the results indicated that between 16 January and 9 April the most common sightings of raptor species by total number of sightings was the prairie falcon (24), followed by rough-legged hawks (Buteo lagopus) (16), common ravens (Corvus corax) (14), golden eagles (9), American kestrels (Falco sparverius) (3), and red-tailed hawks (2). This datum simply shows which species used poles and does not really represent relative populations because some species prefer perching on big sage (Artemesia tridentata), rock piles, and in the canyon. Interactions between species were also recorded during pole censuses. Road censuses were made during the dispersal and post migration periods in order to record the presence of any of the three species under study. These censuses were made irregularly during the eagle tracking trips and were used only as an indicator of the degree of dispersal of the breeding populations. During road censuses, all raptors seen were noted.

Trapping methods: The traps described previously were placed throughout the study area in locations most often frequented by the study subjects. Various lure animals were used in addition to the previously described electric squirrel. During the trapping season 4-12 Townsend ground squirrels, 3 rock doves (Columba livia), and 1 starling (Sturna vulgaris), and 1 great horned owl (Bubo virginianus) were kept for lures. No lure animals were killed during trapping exercises. Attempts were made to capture falcons and hawks but not eagles in 1975. During the 1975 season 2 female and one male prairie falcon and one redtail were

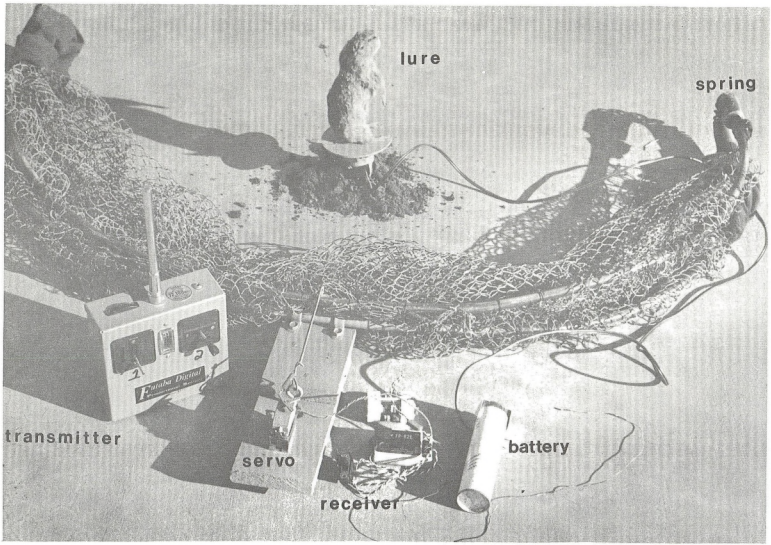

Figure.3. Remotely triggered bownet with rotating ground squirrel lure.

captured, representing three nesting areas. Two of these birds were captured more than once in order to check radio transmitters and the health of the tagged subject. For 1975 we elected to conduct intensive study on two breeding pairs of falcons, one pair of redtails, and one pair of eagles. However, after our selected eagle nest was abandoned we did not trap for a pair of adults but instead selected another nest close to the Intensive Study Area in order to gather some data on breeding eagles.

Data about captured birds: Captured adults were aged, weighed, sexed, and examined for physical condition. Foot pad measurements were taken for use in sexing, should the technique prove valid. All measurements were taken in the metric system as presented in Table 1. No birds were injured in the trapping process.

Determining space use: The flights of all radio tagged subjects were plotted on maps of various scales and the horizontal space use was determined after the home range method suggested by Odum and Kuenzler (1955). The dimensions of the prairie falcon nesting territories were determined by observing and measuring the threat flights directed at other falcons or humans and by recording the daily flight paths of falcons cruising within their territories.

Photographic records: Colored slides and black and white prints were made of study birds, the nesting sites, and the hunting habitat. These photographic records were used for data analysis and were filed for future reference. Colored slides are also used for presentations to the scientific community and the public. Representative samples were provided to the Bureau of Land Management for their records.

RESULTS

Chronology: During the first year of the study a chronology of activities of raptors, their prey and related vegetative changes was compiled. This datum facilitated trapping and also allowed for a better understanding of the behavior of the study subjects as related to the natural changes within the community. The main points of interest are presented for the period from January 1975 to December 1975. Rough-legged hawks were present on the study area during January and remained until the last one was seen on 28 April. Adult golden eagles were present in the canyon and seen perched on the tall powerline support poles and crossbars in January. Courtship for eagles was first noted at the Beecham Nest Site on 16 January when two adults were seen flying together above 4 nests used in previous years. Two adult eagles were also seen soaring together near nests downstream at the Ogden nesting area. During the last week of January and the first two weeks of February adult eagles in and adjacent to the Intensive Study Area were courting and copulation was seen at two nesting areas accompanied by nest repairing. The Intensive Study Area included the falcon nests, the Priest Ranch red-tail nest, and the Beecham eagle nest north to sections 4, 5, 6, 31, 32, 33, 34, 27, 28, 29 and 30. By back dating, the Rapids nest eagle eggs were judged to have been laid in mid-March and hatched about 20 April. Eagles fledged in mid-July and dispersed at various periods throughout the fall (Fig. 4). Prairie falcons were present in small numbers (1-3) in January and became more abundant in February. Our first evidence of a Townsend ground squirrel above ground was from the prey remains of a prairie falcon kill on 20 January. On 6 February, large flocks of red-winged blackbirds (Agelaius phoenicus) migrated into the canyon along the river. People began camping, fishing, and horseback riding in ambient temperatures that were about 4 C (37 F). During February cheatgrass (Bromus tectorum) began to grow and provided food for the squirrels that emerged in large numbers during mid- and late February. Eight pairs of prairie falcons were seen courting in the canyon from the second week of February and were seen in pairs entering canyon crevices used for nesting in previous years. Falcons from the PF1, PF2, Camera, and Dedication nesting areas were seen still courting during the week of 3 March and by back dating we determined the eggs were laid in mid-March, hatched in April, young fledged in June and dispersed in July (Fig. 4). American kestrels were seen courting near a nesting site on 11 March. The red-tailed hawks from the Priest Ranch site (RT 1) were seen courting along the tall powerlines near poles 230-235 and over the Bedspring site on 20 March. Other red-tails were seen copulating through the second week of April. By back dating, the eggs of RT1 were laid the first week of April, hatched in late April, and the young fledged during mid-June and dispersed in mid-August (Fig. 4). Various species of lizards were about by 7 April. Common ravens were seen carrying nesting material in March, and one was seen in an incubating position on a nest built on pole crossbar 248 on 20 March. By 15 May, 5 young ravens had fledged from a nest in the canyon. Some ravens were seen in flocks of 3-5 birds in March and others were again flocked in number of 16-24

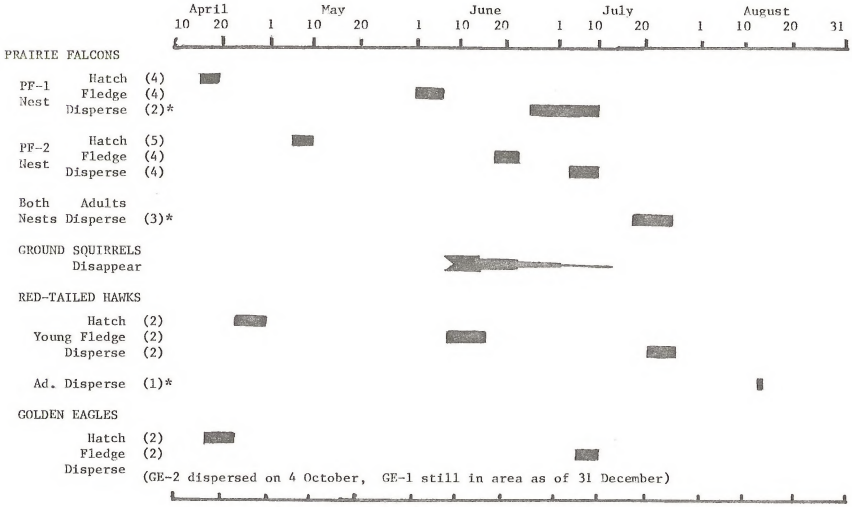

Fig. 4. Chronology of radio tagged birds at study nests, 1975.
(* dispersal of 1 untagged bird not proven)

in August and September, and in smaller flocks of 4-8 in October and November. Raptor migration seemed to peak during mid- and late April when sharp-shinned hawks (Accipiter striatus), Cooper's hawks (Accipiter cooperi), and goshawks (Accipiter gentilis) were seen migrating along the canyon rims. Turkey vultures (Cathartes aura), and ospreys (Pandion haliaetus) were also seen flying close to the canyon. The first rattlesnake (Crotalus viridis) was seen on 1 May and others were seen through June when the ground temperatures reached 56 C (127 F) and ambient temperature was 46 C (116 F). By 25 May the cheatgrass had grown to 15 to 18 cm and was dying, as was the Poa sp. in the area. The young ground squirrels appeared above ground during early March and all ages diminished in numbers through June until all were underground by mid-July. Numerous road-killed black-tailed jackrabbits (Lepus californicus) were found during the first week of July and young rock wrens (Salpinctes obsoletus) were seen "hawking" insects during this period. Pairs of adult golden eagles remained within the study area through December, as well as small numbers of prairie falcons. No red-tailed hawks were seen in the canyon during the fall and winter, nor were any Townsend ground squirrels observed above ground.

Instrumenting subjects: During the 1975 portion of the study a total of 15 raptors were tagged with radio transmitters. A complete family (adult male, adult female, and 4 young) were marked at prairie falcon nest site 2 (PF2), and one adult female and 3 of 4 young (one young fledged before tagging) were tagged at PF1 (Table 1). The adult male and all young (2) were marked at the selected red-tail nest (RT1). All young (2) golden eagles at the Rapids Site (GE1) were marked. Our intention was to place transmitters on all members of selected families, however, this was not accomplished for several reasons. Our policy in 1975 was to avoid any activity around the nests during the incubation period and to trap the subjects away from the nests. We were successful in capturing and marking adult female falcons and the male at PF1 and PF2 but the PF1 male would not decoy to our lures on the canyon rim and flats high above the nest. The female red-tail would also not decoy readily and after several trapping attempts we elected not to disturb her and risk abandonment. Our research plan was to work with the pair of eagles identified with the Beecham nest within our Intensive Study Area and to base all our work around this nesting site. However, on 16 April BLM field personnel from Study I flushed the incubating bird and on 17 April returned to the abandoned nest and counted two eggs. In order to at least gather some data on golden eagles, the 2 young in the Rapids nest (GE1), located two sites west and downstream from the Beecham nest site, were tagged. Because we were unfamiliar with the habits of the adults at GE1 and because we were well into the work on the other species, we elected not to attempt to trap for the adults at GE1.

In general, the study subjects tolerated the transmitter packages and no unusual behavior was noticed that would have biased the results of our study. We did notice that some tagged subjects pulled on the antenna for several days after tagging. Adult prairie falcons did

pull on the whip antennas periodically but did not cause transmitter malfunction. The abuse given the teflon harness material was surprising in that some small holes were ripped in the ribbon. One adult female pulled a transmitter off and it was necessary to use fine stainless steel suture to hold harness straps together instead of the usual 40 lb. test nylon fishline. Young falcons spent very little time pulling on transmitter packages although one falcon apparently pulled off a transmitter during dispersal and another was seen flying with its transmitter hanging from the neck indicating that the junction of the straps had borken. The male redtail pulled on the antenna the day it was tagged and several times the next few days. The 2 young eagles appeared to tolerate the back sack very well and the package after 11 weeks of use by GE-2 showed no damage and there was no sign of harm to the bird because of the package. GE-1 is still wearing its package after 26 weeks and it seems to be working well. The point to be noted in regard to transmission time for all subjects marked is that all subjects were successfully marked until the time that they dispersed from the study area or expired except PF-2 which did remove its package before dispersal. The individual and total transmission times are listed in Table 2. During the week of 8 September,we noticed that GE-2 did not maintain its usual daily behavior pattern and was located near a small stock pond approximately 3.2 km from the eyrie and canyon rim. The bird was located by telemetry and captured by hand on 9 September as it attempted to fly across the pond. The feathers on the head were raised, the wings were drooped, and the palate was swollen, showing an old tan scar created by a case of frounce (Trichomonas gallinae) that was treated by BLM personnel on 10 and 12 May when 250 mg capsules of Emytrol were administered. The swelling was diagnosed as frounce on the evening of 9 September. At 1630 the bird was treated with a pinch of enheptin and force fed 4 chicken necks, and given 10 ml of water. At 22:00 the bird was fed 130 g of chicken gizzards and hearts and was also sprayed with Geisler No-Mite spray to kill hundreds of feather mites. On 10 September the bird was given a capsule of Emytrol and fed 140, 80, and 145 g of chicken livers, legs, necks, and gizzards along with 12 ml of Pedialyte, an oral electrolyte solution for replacement of body water and minerals,containing sodium, potassium, calcium, magnesium, chloride, lactate, and dextrose. On 11 September the bird ate by itself for the first time and was fed about 130 g of rabbit, beef, and chicken meat along with 12 ml of Pedialyte at each feeding. By the 17th the bird had gained from 2.7 kg to 3.6 kg body weight and maintained this weight until 23 September when it was fed 460 g of chicken necks and was released near the nesting site at 16:00. Before being released the 7 g lesion of dead flesh was removed from the upper palate and cleared the nasal passage and allowed free breathing (Fig. 5). By this time the bird was very fiesty and flew well upon release. The bird's activity was observed closely during the following week. Although the purpose of our study is not to guarantee the well-being of our study subjects it is obvious that radio telemetry can be used for such a purpose and in this case did allow a young eagle a second chance at life.

Table 2. Monitoring data for radio tagged study subjects, 1975 season.

Study subject number	Date of last visual or radio contact	Total radio transmission days	Hours position was monitored	Transmission days after fledging	
PF-1	18 June	84	363	--	*a
PF-4	30 June	30	--	22	
PF-5	25 June	25	--	20	
PF-6	9 July	35	--	31	*b
PF-2	8 July	44	228	--	*c
PF-3	25 July	71	365	--	*d
PF-7	8 July	25	--	17	
PF-8	8 July	25	--	17	*e
PF-9	4 July	21	--	13	
PF-10	4 July	21	--	13	
RT-1	15 Aug.	79	377	--	
RT-2	20 July	45	--	34-42	*f
RT-3	26 July	51	--	40-48	*f
GE-1	(31 Dec.)	(200)	--	(177)	
GE-2	4 Oct.	112	--	89	*g
Prairie Falcons					
Adults (3)		199	956	--	
Young (7)		189	--	140	
Total		388			
Red-tailed Hawks					
Adult (1)		79	377	--	
Young (2)		96	--	74-90	
Total					
Golden Eagles					
Young (2) -31 Dec.		(312)	--	(266)	
Total for all 3 species		875	1,333	480-496	

*a. Transmitter quit on 4 June and was replaced on 9 June.
*b. Found dead on 14 July, last movement was heard on 9 July.
*c. First transmitter fell off by 1 May. Retagged on 14 May. Second transmitter fell off on 24 June, but bird was seen through 8 July.
*d. Transmitter quit on 25 July.
*e. Last movement heard on 8 July, and transmitter recovered on 14 July.
*f. Exact fledge date was not determined.
*g. Fledgling was captured by hand on 9 Sept. Sick bird was rehabilitated and released on 23 Sept. with a new transmitter package.

Figure 5. Photograph of 7 gram dead tissue mass removed from the upper palate after treatment of a case of frounce (Trichomonas gallinae).

Space requirements: Both horizontal and vertical use of space by the three species was studied in relation to daily movements, which for the most part, were for securing food. Space use at the nest sites will be described in the section on Daily Activity Rhythms and Interactions. The primary purpose of Study III is to learn how much space is used by the three species under study.

Golden eagle space use: The golden eagles at the Beecham Nest Site were studied until the nest was abandoned on 16 April, after which, our eagle observations were made on the family nesting at the Rapids Nest Site (GE1), which was the site furthest west and downstream (Fig. 6). The Beecham eagles began repairing two of four nests located in close proximity and continued working on two until the last week of February. Both birds carried nesting material and the larger bird, presumably the female, spent much time on the nest placing sticks and resting in an incubating position. The male was often perched on one of three favored perches along the rim of the canyon above the nests. During the week of 10 March one of the two nests was most often frequented and selected and eggs were laid. On 11 March, one of the adults at the Ogden Nest Site (located between the Rapids Nest Site and the Beecham Nest Site) flew from the tall powerline pole area near poles 251-252 straight across to the nest site and the line of flight appeared to mark the western hunting area of the Ogden pair and the eastern boundary of the Rapids pair. The location of 77 eagle sightings of eagles perched along the tall powerline numbered in the 200 series shows that three distinct areas were used. Pole census data gathered for the period from January to June corresponds with data gathered from July to October and indicates that the eagles at the Beecham Nest Site flew out over the flats to and past the section of poles numbered 239 to 251 and the Rapids eagles flew out from the nesting site to the section of poles numbered 254-263 (Fig. 6). The location of the perched eagles along the pole line and the locations in sections 6 and 31, 24 and 25, and 23 correspond with the Beecham, Ogden, and Rapids eagles respectively. The location of the nest sites are indicated as well as the location of a fourth nest site near Sinker Butte that was not studied by us (Fig. 6). The location of 86 perch sites were used to plot the data in Fig. 6 including eagles that perched on big sage, rock piles, and rock outcrops. Eagles in flight were not plotted on this map. The Moratorium Boundary is presented for reference to the BPNA bounary, and the location of cultivated fields and grassy areas are indicated. The eagles perched out from the canyon beyond the tall powerline were not identified as being from a specific nest and were observed during tracking trips of radio tagged birds. This is also why locations were only noted on the north side of the canyon. All of the immature eagles seen during the breeding season were out past the Moratorium Boundary where very few adult eagles were seen and where no active eagle nests were located. Although we could at this time indicate the boundaries of the home ranges for the three eagle pairs mentioned previously based only on field observations as others have done in the literature, we have instead elected not to do so and

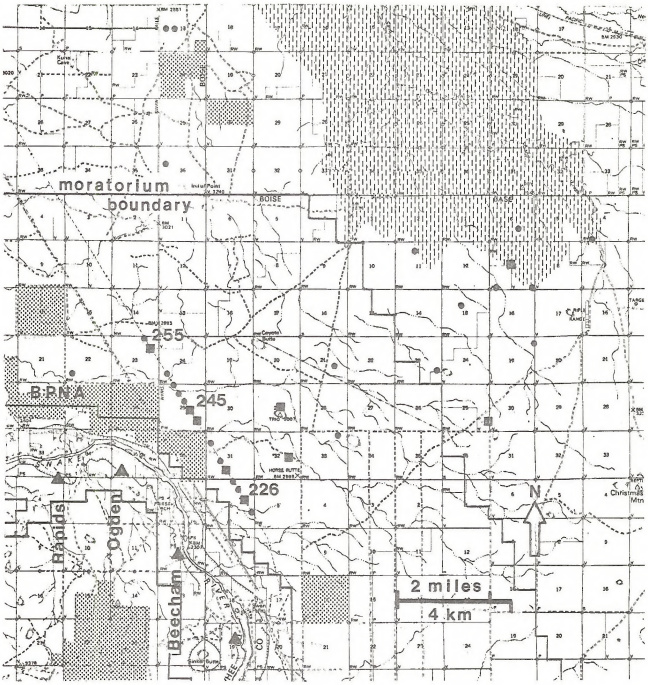

Fig. 6 Random observations of perched golden eagles on the north side of the canyon based on 86 sightings, 1975.

will present this information after it has been supported by movements determined with radio telemetric techniques to be applied during the 1976 season. However, we will present information on the horizontal space use of the 2 young eagles (GE-1 and GE-2) from the Rapids Site. During the period from 15 June (the day of tagging as a nestling) until 31 December the activites of GE-1 were monitored. From the time of fledging during the week of 7 July,the area GE-1 occupied was approximately 2,100 hectares (h) or about 8 square miles. GE-1 appeared to be the less precocious of the two young, did not appear to fly as often or for as long a period as GE-2, the other sibling. During the study period GE-1 perched, roosted and flew along both the south and north rims of the canyon and rarely was seen near the canyon bottom. The majority of the daily flights were restricted to the area along the rim above the nest to the tip of the point to the west, to the rock point east of the nest and just out of view in Fig. 7, but recognized from the map in Fig. 8. When GE-2 was returned to the nesting area on 23 September after being treated for frounce, GE-1 spent the next three days soaring along the north rim of the canyon and over the fields on the north flats. during this time the parent eagles flew over the entire range of GE-1 and at times soared with it. Neither young eagle regularly followed the parents around the home range but instead remained near the canyon rim or just below on favored perches. During September, GE-1 was seen soaring with the parents near the nest site and out over the fields on the north side, but no food exchanges were noted. In contrast, during the last 2 weeks of August GE-2 was not seen closely associated with GE-1 nor with the adult parents and appeared to be hunting by itself although we saw no prey taken during our relatively short observation periods each day. From the time of fledging until dispersal on 4 October, GE-2 used an area of 3,100 h (12 sq. mi.) and as in the case for GE-1 flew and roosted close to the rims of the canyon by the nest site. The flights made by GE-2 that were made to the extreme ends of the range both north and south were in the company of the adults and those far to the north across the canyon were not common (Fig. 8). Several days before being recovered at point A in Figure 8,on 9 September, GE-2 was seen flying over sections 3,9, and 10 more frequently that at any time previous.

From October through December,GE-1 was not seen often associated with the adults which remained within the area of the combined ranges of GE-1 and GE-2. During this time GE-1 appeared to be hunting,and was not seen being fed by the adults but it was very difficult to see what GE-1 was doing when it was on the ground and it may have eaten carrion often. On 26 September GE-1 stooped on a coyote loping across the flat just SW of the nest site but the coyote was not struck. On other occasions GE-1 was seen swooping into small canyons and on 26 September was seen carrying a snake. During these months GE-1 did not appear to be accepted by the adults and when the adults flew along the rim or in the vicinity of GE-1 the young bird stayed on the ground or if flying landed on the ground until the adults passed over and were out of sight. However,

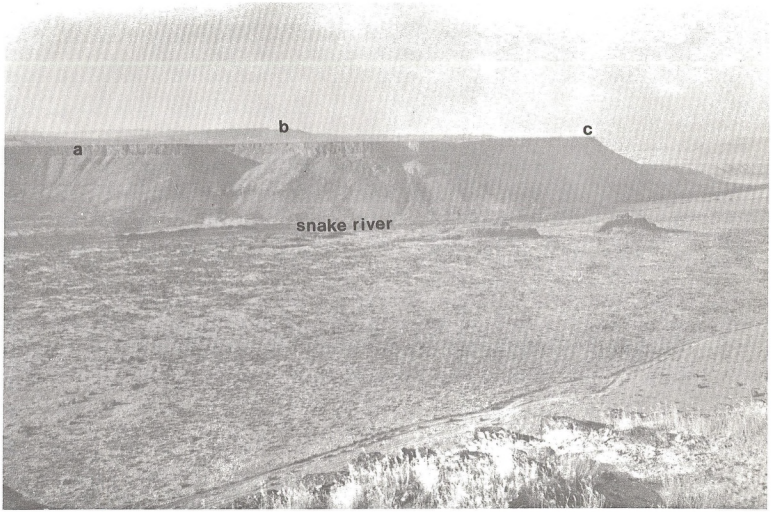

Figure 7. Looking south at the south rim of the canyon and the Rapids (CE1) nest site (a). The ranges of the young (GE-1 and GE-2) extended from the area beyond the left margin of the photograph, south to the rises (b), west to the point (c) and north across the canyon to the flats (foreground).

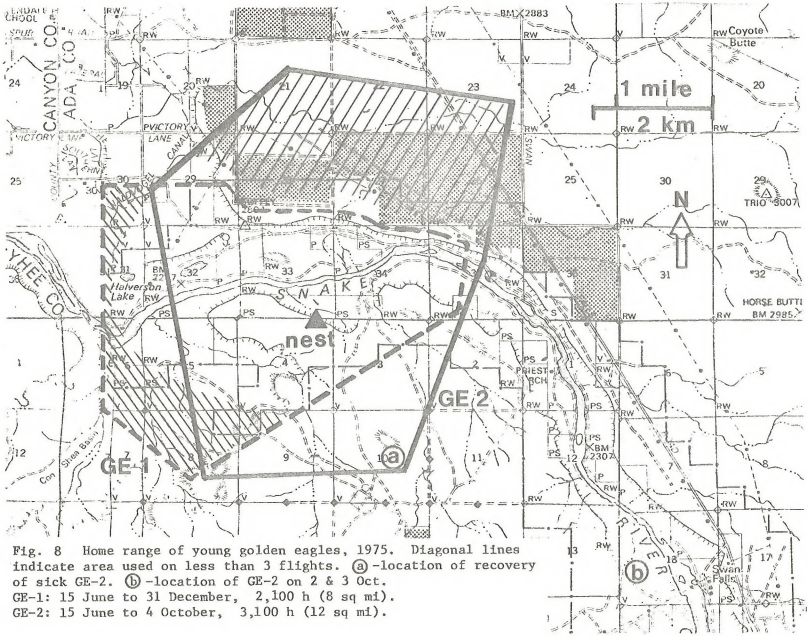

Fig. 8 Home range of young golden eagles, 1975. Diagonal lines indicate area used on less than 3 flights. ⓐ-location of recovery of sick GE-2. ⓑ-location of GE-2 on 2 & 3 Oct.
GE-1: 15 June to 31 December, 2,100 h (8 sq mi).
GE-2: 15 June to 4 October, 3,100 h (12 sq mi).

the adults made no effort to physically chase either young eagle from the home range.

The home range of the adult eagles at the Rapids Nest Site was approximately 4,150 h (16 sq. mi.) based on sight observations and included the area of GE-1 and GE-2 plus about 520 h in the regions of section 22, 23, and 14 in the vicinity of the tall powerline on the north flats by poles 255-263. More information will be gathered on eagles nesting at the Rapids Nest Site in order to gather additional data on horizontal space use during an entire 12 month season.

Red-tailed hawk space use: The redtails at the Priest Ranch Nest Site were studied until all members of the family had left the B.P.N.A.. The adult male was easily recognized because of its dark plumage and was studied from 20 March when its plumage was first sketched during our pole censuses. The male was seen courting with another redtail of typical plumage during the last two weeks of March and regularly flew from the pole line section numbered 225-230 to the nest site. The home range of the adult male (RT-1) based on 71 flights north of the river from 28 May to 13 July is shown in Fig. 9. One pair frequented the area from the power pole line section numbered 251-256 to the canyon in section 23 and 24west of RT-1's range, and another pair frequented the pole section numbered 210-219 to the canyon in sections 7 and 8 east of RT-1's home range. Observations on the redtails occupying the adjacent areas were limited to sight records during daily tracking sessions of the radio tagged birds. The behavior of these pairs was very similar to that of the Priest Ranch pair. The adults at the Priest Ranch Nest Site commonly perched on rock outcrops and ledges close to the nest or above, within about 60m. From the time RT-1 was tagged on 29 May until 20 July, RT-1 used a total range of 2,600 h (10 sq. mi.) of which a 2,300 h (9 sq. mi.) area was considered the primary range (Fig. 9). Almost all of the hunting flights were made over the flats on the north side of the canyon and very few were recorded over the flats south of the nest. RT-1 did most of the hunting and the adult female remained in the vicinity of the nest, although the female was seen flying with the male on 13 occasions, 10 of which were after 12 July and during the period when the 2 young (RT-2 and RT-3) were dispersing. After the ground squirrels went underground and the young dispersed RT-1 extended its range on the north flat by approximately 2,000 h (8 sq. mi.) thereby creating a total home range size of 6,700 h (26 sq. mi.). We feel that this extension was the result of poor hunting success. During the period RT-1 was seen carrying snakes and lizards which were probably alternate prey. RT-1 and the adult female probably were able to succeed at acquiring prey for a longer time after the ground squirrels went underground because of the more diverse feeding habits.

The young redtails at the Priest Ranch Site restricted their daily flights to the vicinity of the nest and flew along the rim and occasionally soared with the adults up the slope above and south of the nest.

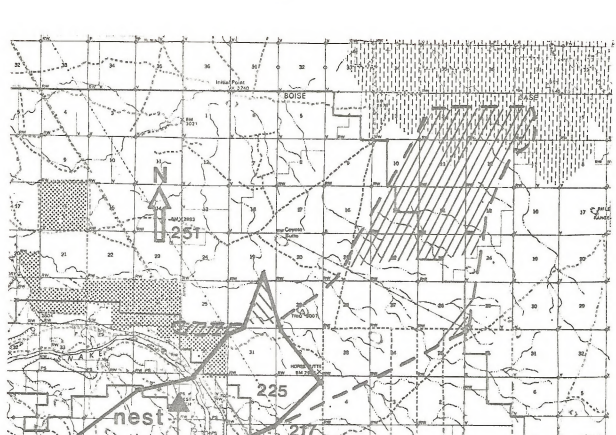

Fig. 9. Area used by RT-1, adult male red-tailed hawk, 1975. Based on 71 flights north of the river and 377 hours of monitoring. Diagonal lines indicate areas observed used on less than 3 flights. Solid line indicates area used from 29 May to 20 July.

PRIMARY RANGE: 2,300 h (9 sq mi).
TOTAL RANGE: 2,600 h (10 sq mi).

Dashed line indicates additional area used from 28 July to 13 August.

ADDED PRIMARY: 2,000 h (8 sq mi)
TOTAL RANGE: 6,700 h (26 sq mi).

However, the young birds did not follow the adults on hunting flights that went beyond the crest of the hill south of the nest or across the canyon to the north.

Prairie falcon space use: During February and March, prairie falcons were seen courting near nest cavities in the canyon and hunting over the north flats and from the tall powerline poles and the small poles along Swan Falls road. During the pre-incubation period (late March and April) prairie falcons made many short flights to the low poles numbered 7 to 55 along Swan Falls road just north of the north rim of the canyon. Other flights were made out to the powerline indicated in figures 10, 11, and 12. The areas used for hunting from the time of tagging until PF-1, PF-2, and PF-3 dispersed are shown in figures 10, 11, and 12. The activities of these birds were observed for a total of 956 hours during which 155 hunting flights were monitored. The tagged falcons hunted while flying low or soaring high over areas with sparse cover of winterfat (Eurotia lanata), cheatgrass or bluegrass (Poa sp.). Up until the middle of May, the falcons hunted extensively over the short grass areas from Horse Butte (sections 32 and 33) to the north rim. However, by 25 May the grasses (Bromus tectorum), and Poa sp.) grew to 15-18 cm in height and the ground squirrels that were once exposed were now hidden over most of the areas not covered with big sage. During the winter months the short grass in these areas had been grazed or broken by sheep while on the winter range. At this time the tagged falcons began making longer hunting flights out to the large grass area that was grazed through the summer by cattle (Figures 10,11, and 12). The National Guard also drove tanks and other vehicles over the cheatgrass areas of sections 11, 12, 13, 24, 19, and 16 west of the indicated rifle range during summer guard camp and created large paths of very low vegetation in which ground squirrels remained exposed throughout the summer. All three radio tagged falcons were flying out to the military area or the large area of grazed grass beginning the last week of May and continued to do so until dispersal. Falcons carried prey from these hunting areas back to the nest sites and ground squirrels were seen in these areas until 6 July. While tracking our radio tagged falcons we also noted the presence of other falcons hunting over the grazed grass and the military area, and these falcons also flew to and from the canyon. Data indicates that these areas of low vegetation and exposed prey caused funneling of falcons from the canyon into the better hunting zone. PF-3 consistently spent the night away from the canyon, and on 4 nights the roost was located 15 km (9 mi.) northeast of the nest (Fig. 12).

The primary ranges of PF-1, PF-2, and PF-3 were 5,700 h (22 sq. mi.), 9,500 h (37 sq. mi.), and 7,000 h (27 sq. mi.) respectively and each had larger total ranges which included areas flown over less than 3 times (Figures 10, 11, and 12).

Daily activities, rhythms, and interactions:

Golden eagle activities, rhythms, and interactions: The purpose of the major study with golden eagles was to monitor post-fledging activities and dispersal behavior of the young birds, and no data was gathered on the

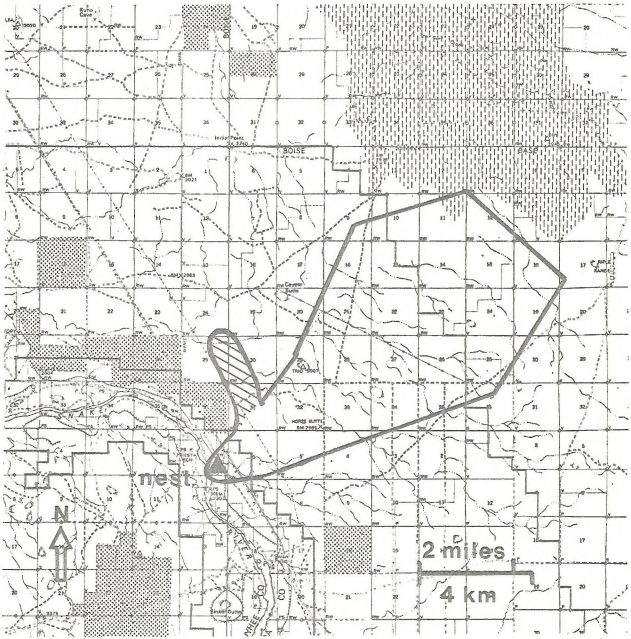

Fig. 10. Area used by PF-1, adult female prairie falcon, 1975. Based on 55 flights observed during 363 hours of monitoring from 21 April to 17 July. Diagonal lines indicate area observed used on only 1 flight.
PRIMARY RANGE: 5,700 h (22 sq mi).
TOTAL RANGE: 6,000 h (23 sq mi).

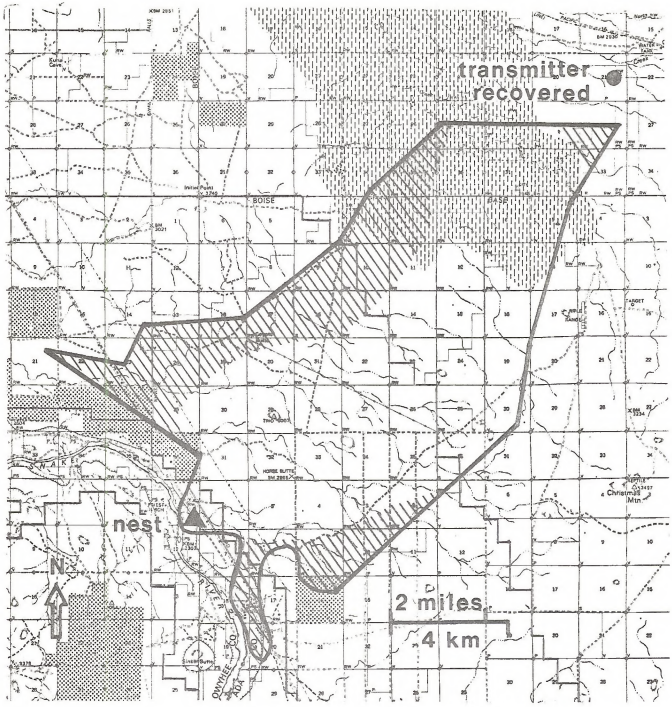

Fig. 11. Area used by PF-2, adult female prairie falcon, 1975. Based on 44 flights observed during 228 hours of monitoring from 30 April to 24 June. Diagonal lines indicate areas observed used on less than 3 flights.
PRIMARY RANGE: 9,500 h (37 sq mi).
TOTAL RANGE: 14,200 h (55 sq mi).

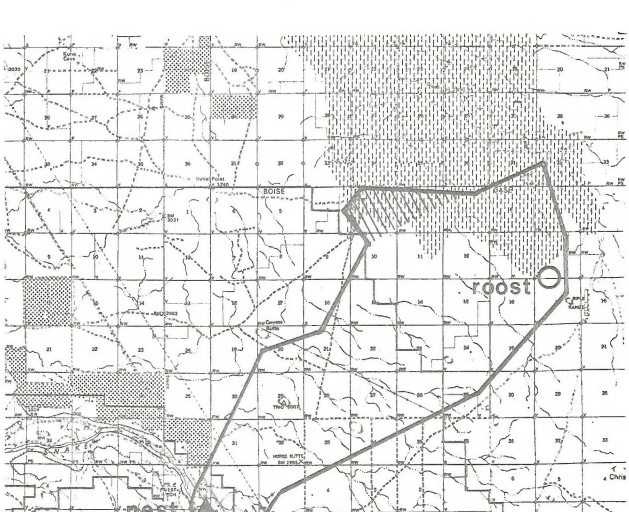

Fig. 12. Area used by PF-3, adult male prairie falcon, 1975. Based on 56 flights observed during 365 hours of monitoring from 17 May to 24 July. Diagonal lines indicate areas observed used on less than 3 flights.
PRIMARY RANGE: 7,000 h (27 sq mi).
TOTAL RANGE: 8,000 h (31 sq mi).

activity of the adults during the egg-laying and incubation period. However, during months of fledging and post fledging observations, we have seen no interactions between the adult birds at the Rapids nest and other adult eagles nesting adjacent to the Rapids site. In October, GE-1 and GE-2 frequently flew well into the vicinity of the Ogden nest and no aggression was seen by the Ogden adults. Most of our observations on the eagle family were restricted to activities close to the nest site and parent adults were seen hunting over the sage flats to both the north and the south of several occasions. Other observations were made on eagles seen throughout the study area and provide some knowledge about intra and interspecific behavior. No daily rhythms were noted other than that eagles feed from the early morning hours or dawn until sunset or after as noted for birds commonly perched on the large powerline crossbars and poles passing through the study area. During the courtship period,there was evidence in one case of two males competing for one female and from the location of this activity along poles numbered 253-263.These birds may have been the Rapids birds. We have already noted that at least one adult and one young from the Rapids nest used this section of the powerline and on 26 November one of the adults was seen hunting about half way between the nest site and the lines. During the first two weeks of February,adult eagles were also seen flying over the area between poles 246-251 and the Ogden nest site, and from poles 223-230 to the Beecham nest site indicating that these were the adjacent pairs nesting on the south wall of the canyon. When these birds were present at all three areas described along the power-line there were no observed interactions involving a defense of hunting or courting area. Perhaps an act of aggression was not necessary as birds at all three locations could easily see down the pole line and observe the presence of other birds and no flights were made between these three general regions along the powerline even when attempts were made to flush birds along the powerline. Instead the birds flew either north or south from the powerline. Adults seen soaring along the canyon rims on updrafts flew only within a certain area and were not observed crossing over adjacent nests. However, birds at the Beecham, Ogden, and Rapids nest sites did cross from the south nest sites to the north floor of the canyon or over the rim, and it appears that there is a resistence to move freely in a lateral direction. In September,October, and November these boundaries were still maintained. For example,adults flew from the area of the Ogden nest site up to the upstream boundary of the Rapids pair and then flew back to perch in the vicinity of the Ogden nests. During October and November the adults from the Rapids nest site still were observed restricting their flights to a certain area in the upstream direction toward the Ogden nest site. It should be noted that birds in immature plumage could fly through the nesting areas of other adult pairs. For example, after being released from medical treatment and recovering within the Rapids nest area,GE-2 flew east along the canyon rim through the nesting areas of the Ogden and Beecham pairs and then returned to its nesting site before dispersing on 4 October. On another occasion an immature bird passed through the Rapids nesting area along

the north rim on 25 September while GE-1 was flying with one parent along the same rim. No interactions were noted as the immature passed by. During August the fledglings did on occasion soar with the adults along the rim above the nest and were fed by the parents. During September and October GE-1 and GE-2 remained close to the nest site and tended to associate with the parent birds less as time progressed. However, the young did not follow the adults around the home range on a regular basis but on several occasions they did move both north and south from the rim in the company of the parents as pointed out in the section on Horizontal Space Use. In October, on at least 2 days, GE-1 and GE-2 were repeatedly "dive bombed" by the parents while the young were on either the rim or talus. Sometimes the young would attempt to land on a ledge occupied by an adult. The adult would flush and the young stayed on the ledge, probably begging for food. Interactions with other raptor species were common but none were life-threatening to the eagles. On numerous occasions eagles coming to land on powerline perches displaced perched rough-legged hawks, redtails, falcons, and ravens with no vigorous acts of aggression. At other times ravens would land within one pole section of perched eagles and on occasion would swoop at them. Eagles soaring over the canyon were often approached by prairie falcons and ravens that made relatively gentle swoops at them and caused no harm. Only on one occasion was an eagle vigorously harassed by another raptor. On 16 June two ferruginous hawks (Buteo regalis) literally forced an immature eagle of unknown age from the air and repeatedly swooped and stooped at it as the eagle jumped around on the ground throwing up its wings in defensive actions. This eagle had passed close to an apparent nesting site out on the flat and was attacked while flying by an area often frequented by the hawks. The attack lasted 12 minutes and ended when the ferruginous hawks departed over a knoll out of sight of the eagle. Eagle interactions with humans were limited to occasions when humans drove automobiles along the powerline and disturbed perched birds into flying. The other negative interaction of humans possibly causing nest desertion was previously described. One 2 occasions a military helicopter entered the canyon to land on the canyon floor and the disturbance chased ravens and eagles from the Rapids nest site. Prairie falcons and redtails were not present at this time. Eagles did hunt over the same area as the prairie falcons, redtails, and ravens, but because of a difference in hunting methods and food habits, no serious interactions were noted. Both eagles and ravens were observed scavenging on carcasses of dead livestock but not at the same time. In these cases it may be that the presence of one species points out the location of carrion to the other species. We found this to be true for the relationship between bald eagles (Haliaeetus leucocephalus) and common crows (Corvus brachyrhynchos) in the Midwest.

Red-tailed hawk activities, rhythms, and interactions: The daily rhythms of the adult redtails at RT1 were studied during 1975 and interactions at both the nesting area and on the hunting range were noted. In addition to the intensive study of the RT1 (Priest Ranch)

birds, observations were made on the activities of pairs of redtails nesting on each side of those at RT1. Before RT1 was tagged with a radio transmitter it was recognizable during flights from the nest by its dark phase plumage which was distinctive from all other redtails within the Intensive Study Area. During the pole censuses through the powerline section 225-230, which was most often used by RT-1, it was noted that RT1 was not often seen prior to 09:30-10:00 MDT. This same rhythm was documented for a 6-week period after RT-1 was marked even when two young were developing in the nest. The majority of the hunting flights were made during a time period from 10:00 to 17:00. When RT-1 brought in prey during the nestling stage of development the male commonly left the prey at the nest and flew out hunting again. This is in contrast to the hunting behavior of the male prairie falcon at PF2. When PF2 returned to the nest with prey during the same period of nestling development it would remain perched near the nest for various periods of time until leaving on another hunting flight. RT-1 was often seen perched on the powerline just before sunset and it did not show intentions of hunting. The female at RT1 never was seen perched on the powerline. At sunset it would fly directly back to the nest area to roost for the night. During the nestling stage of development the female at RT1 was not seen accompanying the male on hunting flights until just before and after the young dispersed. There were no peaks in hunting activity and RT-1 hunted most often during periods of the day when winds and thermals alllowed for soaring, and on clam days (winds less than 9 kmph) RT-1 commonly used the tall powerline for perching. Redtails seen hunting areas adjacent to the RT1 range also showed similar rhythms when observed during our observation periods, including the flights back to the nest site at sunset or shortly after.

No interactions between adjacent pairs of redtails were noted either during flights by the nest or out from the canyon when hunting. From the RT1 nest site the adjacent nest sites could not be seen because of the curvature of the south cliffs. Redtails hunted from poles and big sage and during flight, using methods similar to those of prairie falcons. During April, two ferruginous hawks frequented the area around pole 230 and on 27 April a redtail chased one ferruginous hawk north from pole 230. In general, redtails did not harass prairie falcons or rough-legged hawks nor were redtails often harassed by rough-legged hawks. On one occasion an adult raven was seen attempting to take a captured ground squirrel from the feet of RT-1 as it flew back to the nest site. Prairie falcons did swoop at redtails when redtails were perched on poles or flying, and also took passes at both RT-1 and the adult female within the vicinity of the nest. However, we did not see any birds struck. Humans driving the powerlines flushed redtails as described for eagles. The adult female and RT-1 showed remarkable tenacity to the nest site during banding of the nestlings and prey collection.

Prairie falcon activities, rhythms, and interactions: The daily rhythms of prairie falcons were studied in detail at the PF1 and PF2 nest sites. Observations made during early spring before any adult birds were marked showed that falcons flew out from the canyon shortly after sunrise and often perched on both powerlines throughout and adjacent to our Intensive Study Area. Birds that flew only to the short poles along Swan Falls road would return to the canyon if the squirrels had not emerged above ground. If squirrels were above ground, falcons would hunt from perch locations on poles or crossbars, or would make low flights over the short grass areas while trying to grab exposed squirrels. Flights from poles were usually short distances and at steep angles of attack--the longer ones ending in low swoops. For example, on 7 March one female falcon was seen making 21 short flights (25-150 m) in about 25 minutes. The mean time in the air for 16 flights that were timed was 19.8 seconds and the longest flight time was 28.0 seconds and the shortest was 10.2 seconds. More than one falcon was seen perched on the same crossbar but whether or not these were a mated pair is unknown. At other times one falcon was seen swooping at another, either in flight or when the other was perched. Prairie falcons in flight tended to avoid each other and only on a few occasions were falcons seen chasing each other. Birds in flight were usually flying fast and appeared to always be watching for exposed prey. When falcons did come into close association it appeared as though there were definate avoidance flight paths taken. After bringing in prey, the falcon usually remained near the nest for at least ½ hour before beginning the next round trip. From 22 May to 4 June from the hours of 06:00 to 22:00 the time out of the canyon versus the time in the canyon on a daily basis was determined. The data expressed in percent time out of the canyon was 28.8% for PF-1, 36.2% for PF-2, and 37.6% for PF-3, which illustrates that for the majority of the day, the falcons are perched near the nest site in the canyon. The average number of prey trips per day was also calculated during two periods, one from 22 May to 4 June and correlates in time with the preceding data period, and another from 16 June until the dispersal time in July. Data from the 22 May to 4 June period was based on 89 prey flights (indicated in parenthesis for each bird) and showed that PF-1 averaged 2.5 (26), PF-2 averaged 2.9 (32), and PF-3 averaged 2.7 (30) trips per day. This sample period corresponds with the period of the nestling stage of development during which primary body growth rate takes place. Data from the period after 16 June was based on 54 prey trips which showed that PF-1 averaged 1.3 (18), PF-2 averaged 1.5 (6), and PF-3 averaged 1.5 (30) trips per day and although this is a small sample size of feeding trips it indicates a definate slowdown in food deliveries during the stage just prior to fledging and during fledging. These figures are based on the assumption that prey is brought in on each round trip. Our observations indicate that most flights back to the nest were to deliver prey. Within 2 weeks after fledging young falcons dispersed. It should be noted that the ground squirrel population diminished rapidly during this same period.

Because of the close spatial location of prairie falcon nests on the north walls of the canyon within the Intensive Study Area, 3 additional breeding pairs of falcons were studied along with the radio tagged bird. The three additional nesting pairs were named the Dedication Site nest, the Dedication Point Site nest, and the Camera Site nest; the latter was also studied by personnel from Study VII. The birds occupying these nesting areas did exhibit true territoriality as defined by Noble (1939) as simply being "a defended area". We suggest that true nesting territories did exist and that boundaries in three dimensions were rather elastic but roughly defined by the actions of one of the breeding adults. As in the cases of the eagles and the hawks, the falcons also appeared to have territory boundaries established in part by the degree of visibility from favored perches and the nest cavity to the adjacent nesting territory. The spatial arrangement between the nest sites and territories is shown in Figures 13 and 14. The approximate distance between the nest furthest west (Dedication Site) to the nest furthest east (Dedication Point Site) is 1,250 m (3,750 ft.). The approximate spatial arrangement is shown in Fig. 13 and the pertinent data about the relationships between the sites is presented in Table 3. It should be noted that all nest cavities were located on a vertical portion of the canyon wall and all perched birds had limited visibility to adjacent nesting areas. The birds at the Dedication Site had their vision limited to the east because of the canyon wall projected outward (Fig. 14A). The birds at PF1 had vision limited to the west because of the same projection and could not see PF2 because the latter was stepped back on a vertical cliff (Fig. 14B). Therefore birds at PF2 could not see over the sloping step down to PF1, or to the east around a prominant projection and down to the Camera nest area. The Camera birds had the largest zone of vision and could see west to PF1 (and visa versa) and west to the large rock point between the Camera Site and the Dedication Point Site. As a result, the Camera birds had the largest territory as shown, and demonstrated this by responding to the intrusion of other falcons and humans. This zealous aggression may have been the response of the birds to frequent human intrusion associated with Study VII. At none of the falcon nest sites was there evidence of habituation to human activity. The nesting territories were vigorously defended against other falcons in the dimensions indicated in Table 3 and in Figure 13. On occasion the adults did pursue other falcons out various distances (up to 100 m) toward the river. Most of the pursuit flights were limited to chasing birds that entered within 50 m of the canyon wall and nest. The most common intrusions other than the invasion by adjacent fledglings was from birds returning to the respective nests during hunting fights. On these return flights falcons flew very fast, and defending falcons had little time to launch a defensive flight. There were occasions when the male bird from the Camera Site flew into the canyon and crossed in front of all 3 nest sites to the west and caused the birds on territory to call and make short flights out to protest. During the day when falcons were not perched near the nest they would soar, flap and glide within the territorial boundaries as if to advertise their presence.

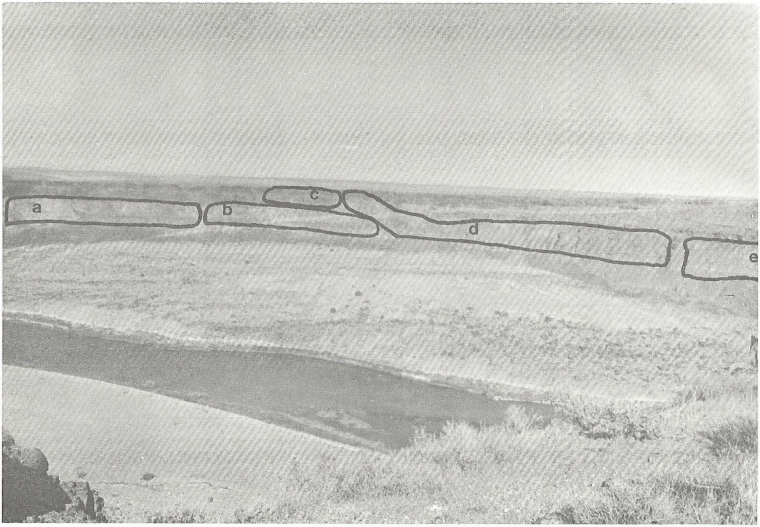

Figure 13. Photograph of the north canyon wall showing the location of the nests and territories of falcons at the Dedication Site (a), the PF1 Site,(b), the PF2 Site (c), the Camera Site (d), and the Dedication Point Site (e).

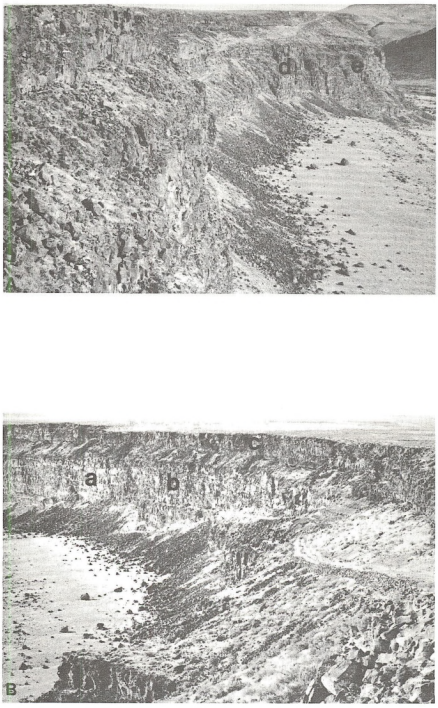

Figure 14. (A) Looking upstream (south) toward Camera Site (d) and Dedication Point Site (e). (B) Looking downstream (north) toward Dedication Site (a), PF1 Site (b), and PF2 Site (c).

We noticed that when both adults of a pair were absent from a nest site, the adjacent falcons "stretched" their territorial boundaries until the defending adults returned. For example, on 9 June when PF-1 was captured and radio tagged it flew out over the north flats at the same time that the male was also out hunting, and the female from the Dedication Site repeatedly extended its eastern boundary around the point toward the PF1 nest site. When PF1 returned, she pursued the invading female once, after which the flights of the invading female were again restricted to the area west of the point.

Both male and female falcons defended the territory and the territory was maintained through the dispersal period of the young. Until the young dispersed, adults continued to vigorously vocalize at a person walking the rim above the nest. During the breeding season there were periods of up to 2 hours when both PF-2 and PF-3 were away from the nest. Throughout the breeding season the adult birds at the 5 nest sites would respond to loud sounds such as a gun shot or clapping of hands by immediately taking flight from perches and calling loudly. During these flights the falcons remained within the boundaries of the territory and after several circles were flown they returned to the perches again. On one occasion motorcyclists drove down the trail from Dedication Point and flushed all of the adults that were present at our study nests. Gun shots from persons violating the closed season caused birds to flush and fly about calling. During the post-dispersal season we used hand clapping to flush adult falcons in order to determine when they left their respective territories. During the banding sessions at the nest sites, the adults called and flew about the territory or out to the low powerlines along Swan Falls Road and returned after we had left the area.

Table 3. Basic data about prairie falcon nesting sites.

	Nest sites				
	Ded. Site	PF1	PF2	Camera Site	Ded. Point
Territory dimensions in horizontal plane from nest cavity (west to east)	40-226	66-266	103-56	146-333	183-x
Territory dimension in vertical plane from nest cavity (up-down)	14-26	20-26	11-11	30-30	40-43
Territory out from vertical cliff is less than	50	40	45	50	50
Distance of cavity from top and bottom of cliff including talus	36-66	31-60	5-86	62-48	x
Nest cavity located on vertical face	yes	yes	yes	yes	yes
Flight path to feeding area on rim and flats about straight up	yes	yes	yes	yes	yes

All measurements in meters. x is no data gathered.

Fledging period: The fledging periods of young at the Rapids, Priest Ranch, and the 5 prairie falcon nest sites are indicated in the chronology in Fig. 4.

Golden eagle fledging: The young golden eagles fledged between 6 and 9 July, at an age of 11 weeks, and during the first 5 days out of the nest they stayed within 75 m of the nest and perched at the top of the talus slope in shady areas on hot, sunny days. By 15 July the young were making short flights up to 200 m from the nest and perched on rocks along the cliff below the rim or along the talus. By the end of July the young eagles were ranging from 400 to 500 m from the nest, utilizing talus slopes, the cliff walls, and the rim for perching (Fig. 8). During the periods from 10:00 to 16:00 the young consistently perched in the shady areas and soaring flights lasted less than 5 minutes. On 21 August, GE-2 made a 70 minute flight that extended north of the nest about 5 km, and one new perch was located 1½ km west of the nest. GE-2 perched on the ground 5 km northeast of the nest for at least 1½ hours on 28 August, but up to this time, GE-1 had not been observed making any flights of over 500 m distance from the nest. GE-2 was the more precocious of the two siblings.

On 3 September, GE-2 was perched near the nest. On 7 September it was not located during a 7 hour period, but on 8 September the bird was located near a stockpond 3 km southeast of the nest. The bird was checked from a distance in the afternoon and appeared sick as it stood on the ground with a drooping head. On 9 September, GE-2 was grabbed by hand and brought to town for examination. After being treated in captivity as described in the section on Instrumenting Subjects, until 23 September when it was released, GE-2 remained near the nest. The first 4 days after release GE-2 remained on the rim or talus by the nest and then began to fly along the rim both east and west of the nest and often soared above a bowl-shaped area with good updrafts along the eastern border of its range along the south rim (Fig. 8). GE-2 remained separated from GE-1 during the day and night and appeared to be chasing rock doves and perhaps chukars (Alectoris gracea) along the talus and ravines on the south canyon. On October 2 GE-2 made a flight east toward Swan Falls and remained on the south rim until 4 October when it was seen back within the boundaries of the home range (Fig. 8). On 4 October GE-2 was last seen and was not located thereafter. GE-1 remained within the indicated range up to the writing of this report and still used the canyon rims and talus regions for roosting and perching, and hunted in the ravines and over the flats and fields on both the north and south sides of the canyon.

Red-tailed hawk fledging: Both young redtails at the Priest Ranch Nest Site (RT1) fledged about 17 June and by 1 July they were flying fairly well, engaged in chases with each other, and made practice stoops directed at big sage on the talus slopes. The first flights did not range beyond a 500 m radius of the nest. Favorite

perch areas included rocks on the slopes, cliffside ledges, and the edge of the canyon rim. Until dispersal, the approximate center of the young's range continued to be their nest, although they were never observed perched on it or within 50 m. As with the golden eagles, the young redtails remained close to the nest site and did not have any conflict with the adults nor were they harassed by other redtails which nested out of sight both up and downstream from the nest site. One pair of prairie falcons that nested just west of the redtail nest did harass the adults when they flew too far west, however, most of the flights by both the adults and the young hawks were up to the rim and east of the nest.

Prairie falcon fledging: Because of the dense breeding population of prairie falcons we had the opportunity to observe the fledging process at 5 nest sites as described in the section titled Rhythms, Activities, and Interactions. Our best data was from the nests at which we radio tagged the young but we found the fledging process at all 5 sites was identical in most respects. Young were seen at the entrances of the nest cavities engaged in wing exercises just prior to fledging after whichthe more precocious nestlings walked and jumped out of the nest entrance and jumped and flapped around the entrance, eventually moving back to the nest cavity. During this activity some young fell from the Dedication Site nest, PF1 Site, and the Camera Site to the talus slope below the nest entrance. At this time the adults flew over the young, but returned to the cliffs to perch as the young called vigorously and flapped and jumped up toward the base of the vertical cliffs directly below the nests. The young eventually made it back to the nest sites and into the territory. One young from the PF2 nest was confused and wandered out of the territory and was stooped on by the adults from the PF1 nest. As the young developed flight skills and occasionally drifted and perched in adjacent territories they were stooped on and struck by defending adults. In several cases flying young were knocked from the air, and perched young from perches. During these bouts the defending adults were then challenged by the parents of the young. No birds were killed during these attacks and all of them worked their way back to the parental territories. Young were fed at the nest and at favored perches within the territory. When food was brought in by an adult the young called loudly and stood with quivering wings, begging. Food dropped at the nest was fought for and the nest cavity remained the focal point for feeding. Young returned to the nest cavity and surrounding ledges even after they developed flying skills.

Dispersal period: The dispersal process of all study birds was studied in detail and except for the golden eagles the exodus from the canyon and the B.P.N.A. was very quick.

Golden eagle dispersal: GE-1 dispersed on 4 October after making flights out of the defined home range, and the flight path was not determined. The exodus was very quick and searches by airplane proved that the initial movement was also very distant. There was no evidence that the parent eagles chased or starved GE-2 out of the area. As of 31 December GE-1 and both parent eagles were present near the nest.

Red-tailed hawk dispersal: The young redtails dispersed from the B.P.N.A. before the adults. On 12 July, RT-2 soared briefly over the Dedication Site and again on 17 July it flew over the north rim across from the nest site. RT-2 dispersed between 14:30 on 20 July and 14:45 on 21 July, and was not located on an aerial search on 22 July. RT-1 was occasionally seen carrying prey toward the canyon but whether or not the adults were still feeding the young prior to dispersal was not determined. RT-1 and the adult female were observed flying together near the nest prior to and following departure of each of the young.

On 23 July, RT-3 was spotted flying along the north side talus opposite Priest Ranch. The following morning, RT-3 was observed perching in the orchard just west of the ranch. No signal was received at 12:15 on 26 July, but at 14:40 a signal was monitored to the north as RT-3 began its dispersal (Figure 15). Throughout the afternoon, the redtails signal cut in and out as if the fledging was flying low, or it may have landed several times along the way. The last faint signal was at 30 degrees magnetic from highway I-80. At that time, we suspected that the bird had landed near the Boise River, but after an aerial search that evening, and another search the following morning, it was determined that RT-3 had entered the Sawtooth Range and continued traveling north. Later aerial searches for RT-1 demonstrated that in the extremely rugged mountainous terrain, a range of only 5 km (3 mi.) from the airplane to a perched bird could be expected.

The adult redtails stayed within the home range until the young had dispersed. After the dispersal of the young, RT-1 and the adult female were seen flying together out over the north flats on 28 and 30 July, and on 1, 4, and 8 August. Both flew back to the nesting site until 14 August at 11:35, when RT-1 was monitored flying northeast at the junction of Kuna-Mora road and Pleasant Valley road north of the canyon (Fig. 16). By 12:51 the transmitter signal quit as the bird passed north over the Boise Front near Table Rock. An immediate aerial search began, but the bird was not located and had probably perched in the forested area with uneven terrain. Later in the afternoon the signal was detected again to the east while monitoring from Shafer Butte Lookout and during an aerial search on 15 August, RT-1 was pinpointed at a night roost 15 km east of Idaho City (Fig. 16). The dispersal flight of 14 August was of a straight line distance of 79 km (49 mi.). At 10:50, on 15 August, RT-1 took off, circled for 50 minutes, and headed further east into the very rugged Sawtooth Range and the signal was last detected from Sunset Peak Lookout at 12:42. During an aerial search an hour later the bird was not located and because of the time and money involved in further aerial searches in relation to the data that may have been gathered the monitoring of RT-1 was discontinued.

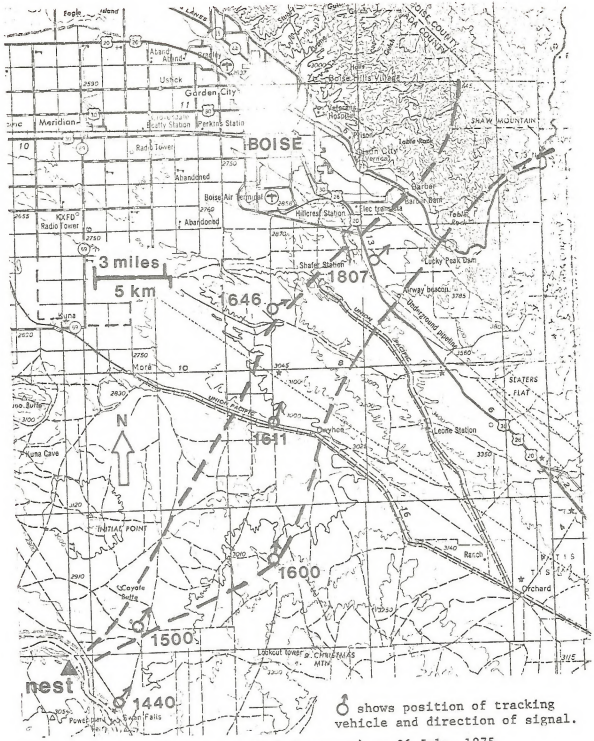

Fig. 15. Dispersal flight of RT-3 (immature) on 26 July, 1975.
1440 Hear first signal to northeast from Swan Falls road.
1611 Hear only an intermittent signal faint to north.
1646 After driving ahead and monitoring, returned to state prison and received loud signal. Bird may have been on ground nearby, but possibly was already in the foothills.
1807 The last faint signal was heard.
2030-2130 An aerial search fails to relocate RT-3.

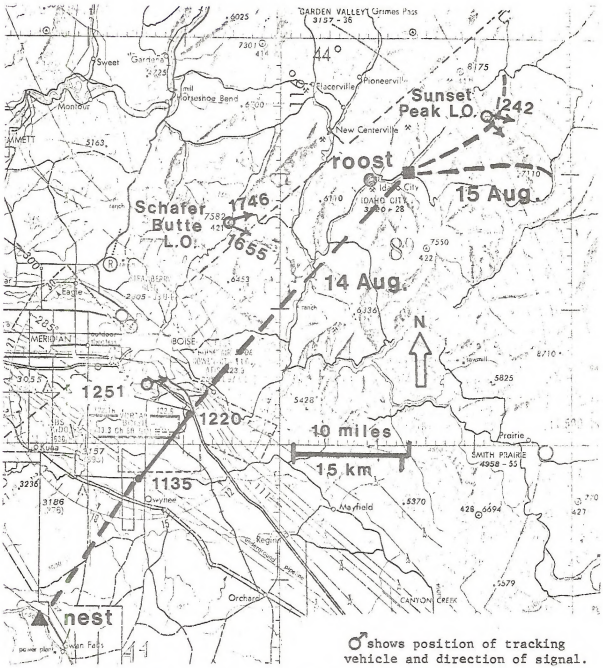

Fig. 16. Dispersal Flight of RT-1, adult male red-tailed hawk, 1975.

14 Aug. 1135 RT-1 pinpointed flying over Kuna-Mora road.
1220 Bird crossed I-80, computed speed of 9 mph.
1251 From airport, signal quits as RT-1 passes over Boise front.
1325-1515 Unsuccessful aerial search.
1655-1746 Monitor signal to east from Schafer Butte look-out.

15 Aug. 0757-0835 Aerial search pinpoints RT-1 near Idaho City.
1050 RT-1 takes off from roost and travels east.
1221-1242 Signal monitored from Sunset Peak look-out.
1340-1435 Aerial search fails to locate RT-1.

16 Aug. 1340-1435 Unsuccessful aerial search.

Prairie falcon disperal: As with the young redtails, the prairie falcon young dispersed before the adult parents. By the last week in June, young prairie falcons began dispersing from the parental territories (Fig. 4). Prior to these dispersal flights young falcons were not observed following their parents out from the canyon on hunting flights, but they were on occasion seen up on the rim and within 30 m of the rim on the flat running on foot chasing insects. The young from all 5 nest sites made this vertical shift up to the rim areas above their nesting sites rather than going down to the canyon bottom. By late June, territorial boundaries began to become nebulous, although, young that invaded areas close to other nest sites were chased out. Feeding flights by the adults were reduced as previously mentioned and the ground squirrels were going underground for the winter. Young falcons numbered 6, 8, 9 and 10 made flights to areas not frequented by the adults (Fig. 17).

PF-5 dispersed between 10:45 on 25 June and 10:25 on 26 June. PF-4 dispersed between 10:00 and 16:50 on 1 July.

PF-10 was not detected near the canyon at 08:15 or 10:00, but at 11:15 it flew to the north rim from somewhere north of the rim. It then continued to fly west along the rim. By 12:50, it had perched on the north rim by the trail out of the canyon in the area identified as Dedication Point which was close to the upper territorial boundary of the Dedication Point falcons (14A). At 16:00, PF-10's signal was located west of the nest site along the north rim toward Halverson Lake (Fig. 17). On 2 July it remained on the north side of the canyon 2-4 km west of the nest site and on 3 July was perched across the canyon on the south rim. On 4 July, PF-10 was 3-4 km west of the nest site on the north wall, and had dispersed from the area by 09:30 on 5 July.

PF-7 was seen flying out from the rim on the north flats over the Bedspring area on 8 July and returned to the rim until 15:00. By 12:00 the following day it had dispersed from the area.

On 10 July PF-9 was located 10 miles north of the nest and was perched on a clump of dirt and taking a bath in an irrigation sprinkler. The body harness strap had separated from the junction and the transmitter dangled from the neck like a pendant. At 10:35 on 11 July, a signal was heard to the east from Swan Falls Road, but dropped off abruptly as if the bird had landed. On subsequent aerial flights the transmitter signal was not detected and the bird had at least dispersed from the desert and the B.P.N.A.

On 9 July at 12:00 PF-6 was located flying south across the canyon out over the south flats. On 10 July it was back within the canyon and on 11 July the signal remained constant and the location did not change. The signal was monitored daily and the bird remained in a fixed

location on the south side of the canyon floor. On 14 July, the carcass and transmitter were recovered from tall grass near the river and because of the poor condition of the carcass the cause of death was not determined. Personnel from Study VII found 2 dead fledglings on 15 and 16 July in the canyon by the study nest sites and it appears that this may be a period of high mortality for young falcons. Falcons dispersing at this time must feed for themselves at a time when favored prey is very scarce.

On 8 July, PF-8's signal was located on the south side of the canyon to the west of the nest site (Fig. 17). By 11 July it was determined that the location of the signal was not changing and on 14 July the transmitter was recovered on the south rim 2½ km west of the nest site. All 4 harness straps had been severed and there was no trace of the bird or any indication of a carcass. This particular set of circumstances had not been seen before in any of our telemetry studies on 17 raptor species.

Aerial search flights were flown on 7, 10, and 19 July and determined that the instrumented young had left the B.P.N.A. and the desert both north and south of the canyon. The Snake River canyon was searched from Marsing to Grandview 40 km each direction from the nests, and a 15 km radius of the nests was checked twice. One search included the northern slopes of the Owyhee Mountains and the southern face of the Boise Front of the Sawtooth Range. Evidence suggests that when the prairie falcons disperse they fly completely out of the B.P.N.A. and the desert within about 2 days.

The radio tagged adults remained in the parental territory until their young dispersed. On 17 July, PF-1, the adult female, spent much of the day perched near the nest. On 19 July it was located at 10:00 during an aerial search and was hunting in the usual area northeast of the nest. When checked on 20 July the falcon was not located.

On 24 June, PF-2's transmitter fell off and was located on 22 July, 21 km (13 mi.) northeast of the nest site. PF-2, the adult female, remained within the nest site until 16 July as determined by direct observations and by defensive attacks directed at us as we checked the occupancy of the 5 territories.

On 24 July the pulse rate of PF-3's transmitter began to slow and the battery failed several hours later. PF-3 was last seen on territory on 24 July.

At least one of the parents at the Dedication Site, Camera Site, and the Dedication Point Site remained on territory until the young had dispersed. By 6 July, the territorial defenses at the four active sites dropped off and the adults didn't even respond to the presence of humans other than to give an occasional call. During a territory census on 1 July, the adult female and 2 young were present at the Dedication Site territory. However, only the adults were seen during subseqent

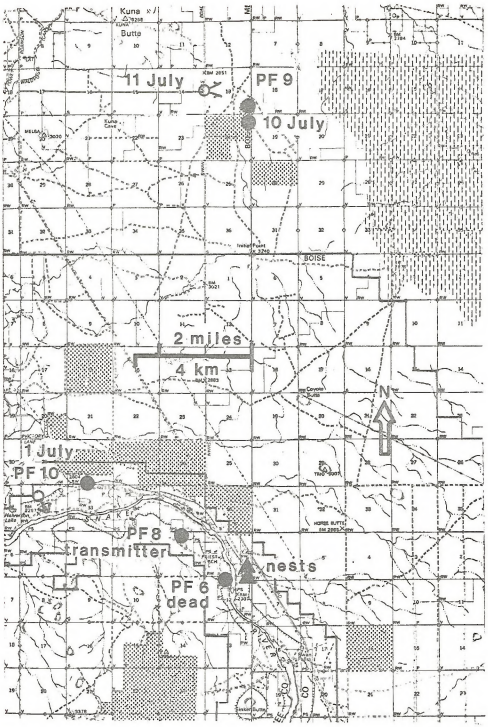

Fig. 17. Locations of young prairie falcons away from their nests, 1975.
shows position of tracking vehicle and direction of signal.
shows position of the bird or transmitter.

censuses on 5, 6, and 9 July. Only the adult male was present on 9 July. The adults and the 2 young at the Camera Site territory were present during censuses on 6 and 13 July, but only the parents were present on 16 July. The adult male was seen on 20 July after which no falcons except PF-3 were present on territories. At the Dedication Point Site 2 young and one adult were last seen on 16 July and no young were seen when censused on 20 July nor were the parents present.

In summary, the nesting territories began to break down during the last week of June. Young falcons dispersed randomly and only 1 or 2 adults remained on territory. After the middle of July no falcons were seen maintaining a territory and exodus from the B.P.N.A. appears to be rapid.

Plans for next season: The 1975 field work has been evaluated and the following work will be attempted during the 1976 field season.

1. To continue to monitor the activities of the radio tagged young eagle GE-1.
2. To capture and radio tag adult golden eagles within the B.P.N.A. and monitor their habitat use and relationship with the young.
3. To capture and radio tag adult prairie falcons within the Intensive Study Area and distributed throughout the entire B.P.N.A. from Halverson Lake to Grandview, Idaho for space use studies.
4. To capture and radio tag adult red-tailed hawks within the Intensive Study Area and distributed throughout the entire B.P.N.A. from Halverson Lake to Grandview, Idaho for space use studies.
5. To radio tag a selected number of young from nests of each species under study in order to gather further information on survival and dispersal.

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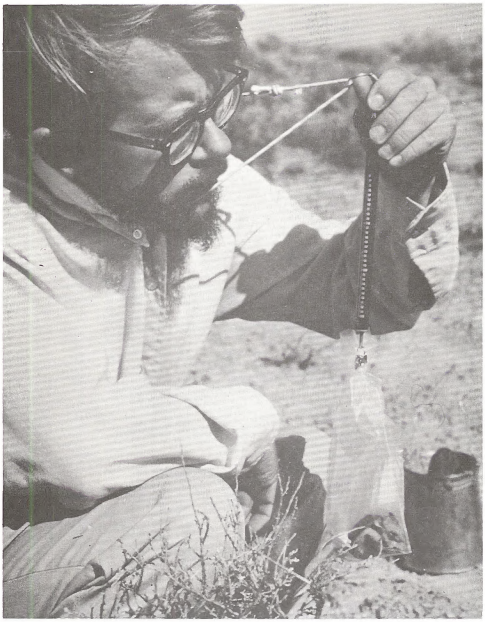

Jon Montan, Research Associate Study IVa, weighing deer mouse.

ANNUAL REPORT

Study IV-a: Density and Species Composition of Birds and Mammals, Snake River Birds of Prey Natural Area, Idaho

Contractor: Department of Wildlife Science, Utah State University

Investigators: Dr. Michael Wolfe, Principal Investigator
Jon R. Montan, Jr., Research Associate

Project Support: U. S. Department of the Interior, Bureau of Land Management Contract No. 52500-CT5-1003

Objectives:

1. Stratify the study area into major vegetation types and land-use patterns from existing aerial photographs and other means.

2. Sub-stratify the major vegetation types into basic land-use types, and sample the major prey species by acceptable statistical and censusing techniques.

3. Specifically, sample for prey species in those areas identified by radio telemetry efforts (Study III) to be intensively hunted by golden eagles, prairie falcons, and red-tailed hawks. Aspects of vegetation composition, cover, physiography and any other factors will be studied to determine the importance of prey vulnerability to predation.

4. Assess and compare prey densities in the different habitat and land use types to ascertain the possible effects of different land uses upon prey densities.

5. Ascertain seasonal and yearly changes in prey species' composition and densities.

6. Calculate annual prey population densities in terms of biomass within each strata of the total study area and in the areas intensively hunted by raptors.

Annual Summary:

Rodents, lagomorphs, gamebirds, and passerines were censused with varying degrees of success during 1975. A snap-trapping method was developed to extend accurate density estimates in small, well-defined locations to much larger areas throughout the entire study area. The annual cycle of rodent population fluctuation was documented. A vegetation map was made of the entire study area but has yet to be drawn in final form pending further aerial photographs and ground-validation.

Plans for Next Field Season

Snap trapping will be used extensively throughout the study area to accomplish objectives 3, 4, 5, and 6. A major effort will be made to quantify differences in species composition and relative densities in ecotones between major vegetation types and between native and agriculturally altered areas. Lagomorph trapping will be expanded, both in terms of the trapping period and the number of locations. Crow counts will be substituted for the roadside count method used this year in obtaining indices of pheasant abundance. Chukar partridges will be censused by means of recorded calls.

METHODS

Vegetation analysis:

A vegetation map of the entire study area was prepared by projecting aerial infra-red transparencies onto Mylar overlays of 7.5-minute USGS quadrangle sheets. The map will be reduced to 1 inch = 1 mile (1 cm = 0.64 km) and drawn up in final form. Additional ground validation would be desirable but is not essential at this time.

Enumeration of prey densities and biomass:

Rodents: Resident rodent species can be classified according to their habitat preferences (Appendix 1). Different census methods were employed depending on whether or not a rodent was a rock-dweller, a riparian occupant, or an open rangeland inhabitant. The former two categories were inventoried by a combination of snap-trapping, live-trapping, or both. Captures were never so numerous as to permit reliable density estimates. Only relative indices of abundance were obtained.

Densities of open rangeland rodents were estimated from capture data, obtained from live-trapping grids in representative vegetation types. Based on the results of the initial vegetation analysis, grids were established in five types on the north side of the canyon and in three vegetative communities on the south side. Respective grid locations are given in Appendix 2. Vegetative composition of individual grids was determined by the line-intercept method, recording the number of centimeters occupied by the basal area of various plant species along transects of 30 m. The results of the vegetation surveys are given in Table 1.

Live-trap grids comprised a 10 x 10 arrangement of Sherman traps (8x 8 x 26 cm), spaced at 15 m-intervals. The traps were baited with a mixture of peanut butter and rolled oats, and were operated for five-night periods in spring, summer, and fall. The traps were opened between 1500 and 1800 hours and checked between 0700 and 1100 hours before the mid-day heat killed the animals. Animals were marked by toe-clipping and ear-taggging with fingerling tags. Sex, age, and weights were recorded. Live-trapping data was analyzed with the aid of a computer program written by Kim Marshall, of the USIBP/Desert Biome at Utah State University.

Concurrent with the operation of the live-trap grids, snap-trap lines of 50 traps spaced at 15 m -intervals and baited with peanut butter and rolled oats were set near the live-trap grids, but not so close that grid-marked animals would be sampled. The decision as to where to place the snap-lines was arbitrary, but usually no part of the snap-line was closer than about 500 m from the grid. In addition, several snap-lines were run crossing selected ecotones to evaluate prey concentration effects.

Lagomorphs: Cottontails (Sylvilagus nutallii) were live-trapped at rocky sites during spring, summer, and fall. Homemade live-traps were placed in lines of 8-9 traps spaced at 60 m -intervals. Between the cottontail traps were seven live-traps "Havahart" designed to catch woodrats (Neotoma sp.), but not cottontails. Lettuce was used for bait. Traps were set in the evening and checked in the morning. Cottontails were marked with colored washer-type ear tags (as were jackrabbits) and a list of all animals marked was filed with the Idaho Fish and Game Department. Woodrats were marked with fingering tags.

Jackrabbits (Lepus californicus) were censused with the assistance of BLM personnel during the spring and fall by walking sixty 1.6 km transects located throughout the study area. These transects had been previously established by BLM biologists. In addition, night-lighting was experimented with as a means of capturing animals for the estimation of local densities. A spotlight-equipped vehicle was driven along a selected route at approximately 15 km/hr. until a jackrabbit was spotted. The driver then accelerated to overtake the animal and extinguished the headlights, leaving the spotlight as the sole light source. Assistants equipped with landing nets jumped from the vehicle and captured the hare. Animals were ear-tagged by the same method as used for cottontails. Sex, age, and weights were recorded. Live-trapping was also attempted to evaluate the concentrating effect of a beetfield on the hare population in an adjacent sage brush stand. Folding live-traps (38 x 38 x 102 cm) were arranged in a square 4 x 4 grid. Trapping and handling procedures were the same as described for cottontails.

Avian prey: Pheasants were censused by driving eight different routes in major agricultural blocks throughout the study area in early May and observing birds as they flushed. When a bird was sighted, a dog was sent out to flush any birds remaining under cover. Due to the general lack of cover except immediately near the road edge, it was felt that this method would yield a better estimate than the traditional crow-count method (Kimball 1949). Densities of pheasants were estimated using the Gates formula, which is the same method used in the jackrabbit transects (Gates et al. 1968). Biomass was calculated by multiplying the mean weights of adult males and females by their proportion (Appendix 3). A hen:cock ratio of 2:1 and a young:hen ratio of 5:1 was assumed in these calculations based on consultation with Chuck Jensen, Regional Game Biologist with the Idaho Department of Fish and Game. Sex ratios observed in this study were not used because of small sample size.

An attempt was made to census chukar partridges when they came to water in Snake River canyon in May and late July. Two observers walked along the shore, the one nearest the river acting as a beater, and the second, following slightly, counted birds as they flushed or ran across the road which paralleled the river. This method yielded no meaningful results. In 1976, a new method based on response to recorded calls will be employed (Oeklaus 1976).

Passerine birds were censused by walking linear transects (450 m) located within the small mammal live-trap grids. Counts were made between sunrise and 0900 hrs. Flushing angles and distances for the various species were estimated and a crude density was calculated after Emlen (1971). The weights used in the calculation of biomass values are found in Appendix 3. Counts were replicated once in late spring and again in the fall.

RESULTS

Rodents: Only deer mice (Peromyscus maniculatus) were captured in sufficient numbers to permit accurate density estimates (Tables 2a-c). Other species were far less numerous, but nevertheless exhibited seasonal fluctuations which were detectable (Tables 3a - c). An analysis of the computer program results showed that the geometric regression of capture frequencies method (Edwards and Eberhardt 1967; Marten 1970) yielded expected distributions which agreed well with the observed distribution of capture frequencies. Mean home range for a given species on a grid was calculated by the method of Jennrich and Turner (1969). The area actually sampled by the grid was estimated by expanding each side fo the grid by the diameter of a circle whose area equals the Jennrich and Turner home range. If the movement of individuals was so small or infrequent that no Jennrich and Turner home range could be calculated, a regression equation was used to estimate the home range (Balph 1973). The equation was $Y = 0.078 + 0.098X^c$; ($r^2 = 0.65$), where X equals the mean distance traveled between successive captures as measured in grid units. In this case, one grid unit was 15. Y is the home range in hectares. If no mean movement between successive captures was observed (because the animals went into the same traps repeatedly) then this parameter was arbitrarily assumed to be 15, the intertrap distance.

Figure 1 illustrates the relation between the snap-trap index (Table 5) and live-trap density estimates for P. maniculatus. The snap-trap index was calculated as (captures)/(trap-nights - sprung traps - missing traps). The effect of ants stealing bait was evidently small because the wooden treadles retained the smell of the bait. Apparently, the stems of sagebrush restrict movement of deer mice, and presumably other rodents, resulting in fewer captures per unit effort in the big sagebrush type. Both regression equations correlate well, and when tested for equivalence of slope the F-value of 101.1 was highly significant ($p = 0.01$; $df = 1, 7$).

An analysis of rodent distributions along ecotones by the use of snap lines yielded two important findings. Only in spring were there enough captures to observe an effect using the present method. Secondly, in only two cases was there any noticeable concentration of rodents in an ecotone. One was in the sagebrush-cheatgrass ecotone south of the Snake River, and the other was near a rocky outcrop on the shadscale-big sage snap-line, also on the south side of the Snake River.

Capture data for woodrats are grouped with cottontail capture data (Table 6) because both were subjected to the same trapping regime. Bushy-tailed woodrats (N. cinerea) were the only woodrat species caught within the canyon proper. With the exception of four bushy-tailed woodrats, only desert woodrats (N. lepida) were caught along the canyon rim, and nowhere else. Bushy-tailed woodrats were also captured at Trio Butte in the Kuna desert. Sightings of this species, as well as stick nests, were made in greasewood along Rabbit Creek near Murphy. It appears that bushy-tailed woodrats are generally more numerous than desert woodrats on the study area.

An effort was made to sample meadow voles (Microtus montanus) in an irrigated pasture habitat at Evans Ranch, Melba. Fifty snap-traps were set in "runs" in rows of five traps, spaced at ten intervals. The traps were checked morning and evening every day of the week 10 August - 15 August, 1975. No meadow voles were captured during the 250 trap-nights and 250 trap-days in the field proper, but one was captured during the night in a line of ten snap-traps set out less than a meter from the water in an irrigation ditch. In 1976 a combination of live-trapping and later snap-trapping will be used to census voles.

No marmots (Marmota flaviventris) were captured in 1975, but they are common in the canyon and in rocky outcrops, especially near alfalfa fields. An effort will be made to trap marmots using larger traps in 1976.

Lagomorphs: Cottontails were found near rocky outcrops, along the canyon rim, and in the canyon proper. Dense greasewood and weedy borders of agricultural areas also harbor populations. Following tracks in the snow revealed that, indeed, cottontails may be more widespread than previously thought. Intensified trapping in 1976 may reveal a sparse population inhabiting non-rocky, rangeland areas. Only one pigmy rabbit (Sylvilagus idahoensis) was observed in 1975 near the "Rye Patch" farm on the south side of the Snake River. Captures and density estimates are found in Table 6.

Results of the jackrabbit transects are summarized in Table 7. Gates transect indices were converted to density estimates (hares/km^2) by multiplying by 1.43, the conversion factor applied by Gross et al. (1974). This factor may not apply to this area, thus drive counts

would be very desirable to establish the "true" factor for this area. Biomass estimates were calculated using the mean weight of a jackrabbit. Spotlighting proved to be a good method of marking a large number of animals in a short period of time.

Results of jackrabbit live-trapping (Table 6) showed no obvious tendency of the rabbits to congregate along Victory Lane. Captures did appear to be more frequent near intermittent streams and succulent vegetation along these streams showed evidence of having been heavily cropped by jackrabbits. A check of the beet foliage in the field across the road revealed no utilization by jackrabbits for food. Maximum detectable movement of a jackrabbit during the trapping period was 60 m. The area actually sampled was therefore the 6.4 ha grid plus a 60 m-strip on three sides (beet field not included). This amounted to 11 ha or 13.2 ha if the beet field was included. The Schnabel estimate of jackrabbit numbers gave a mean value of 33 jackrabbits, or 2.5-3.0 hares per ha as a density estimate. The estimate obtained, when comparing these estimates with using the number (15) of the jackrabbits actually caught on the 6.4 ha grid, was 2.4 hares/ha.

Avian prey: Results from the spring pheasant counts are given in Table 8. Chukars were sighted by various workers, but the information was largely subjective and fragmentary. It appears that chukar are more abundant on the south side of the Snake River, perhaps due to lower hunting pressure from sportsmen. All the sightings were near or in the canyon proper, along the rim and at rocky outcroppings. In most cases the birds were not farther than 2 km away from water. Harvest records from the Idaho Department of Fish and Game indicate a better chukar harvest in 1975 than 1974. Table 9 shows density and biomass estimates for passerine species obtained from Emlen transects.

DISCUSSION

Rodents:

The most noticeable change observed in rodent numbers was their rapid decline between spring and summer. Only least chipmunks (E. minimus) and grasshopper mice (O. leucogaster) appeared to increase as summer approached, only to wane with the onset of fall. If it can be assumed that ingress and egress were equal on the live-trap grids, then changes in rodent densities reflect births minus deaths. The bulk of mortality is undoubtedly due to predation. In addition to avian and mammalian predators, reptiles are believed to take a high toll.

Of importance is the data on survival, as indicated by P. maniculatus (Table 4). This information suggests possible differential vulnerability of rodents with respect to vegetation type.

Populations in all grids declined, but populations in big sage (grid 3) showed the highest survival over the year. If survival is, in fact, higher in big sage then this type may serve as a rodent "source" with other areas representing "sinks". Supportive evidence can be seen in the slopes of the regression lines in Figure 1. For a given snap-line value, the density of P. maniculatus in big sage is about four times that of all other vegetation types.

Kangaroo rats (Dipodomys sp.) showed a preference for sandy substrates, which is well documented from other studies. The chisel-toothed kangaroo rat (D. microps) exhibited a definite preference for shadscale, explained by differential feeding patterns (Kenagy 1972, Johnson 1961). Observations of tracks after dragging dusty roads the previous night support Larrison and Johnson's (1973) conclusion that roads facilitate the spread of kangaroo rats (mostly D. ordii) by disturbing the soil and creating good burrowing conditions.

All rodents considered in this study were nocturnal or crepuscular with the exception of least chipmunks and white-tailed antelope squirrels (Ammospermophilus leucurus) which were diurnal. For diurnal raptors these two species would provide little alternate rodent prey should the Townsend squirrel population undergo a drastic decline. Least chipmunks, which are restricted to the dense big sage type, are difficult for raptors to catch. White-tailed antelope squirrels do not appear to be abundant, and are largely restricted to the south side of the Snake River. This area is outside many of the raptors' traditional hunting areas, as well as being heavily farmed. Many questions exist concerning whether or not raptors would utilize the white-tailed antelope squirrel in times of a derth of other prey, or whether they would simply abstain from nesting.

Lagomorphs:

Longer trapping periods in more areas are necessary to obtain cottontail density estimates with smaller confidence intervals. This will be done in 1976. Drive counts must be made to determine a factor to convert jackrabbit indices to density estimates. These counts must be made before the onset of breeding in spring or after it ceases in fall.

Birds:

Pheasant crow counts may be a more efficient means of deriving indices of density than the method used this year. The main advantage crow counts have is that a single person can conduct the survey; presently two persons and a dog are required. In order to reliably estimate density from crow counts, one must assume that the maximum distance at which crowing cocks can be heard is constant, known, and thus represents the same effective sampling area from station to station.

The method used now assumes that all birds along the transect routes will be seen. Under most circumstances in the BPNA with cover being largely restricted to a few meters from the roadbed in the spring, this assumption is near to being correct. Nevertheless, the greater number of census routes that can be run using the crow-count method may compensate for their relative inaccuracy. Thus crow-counts will probably be used in 1976.

Passerine census using the Emlen method are rather crude. Better methods would include location of nesting individuals (Williamson, 1964) on a grid or sweeping defined areas with mist nets. These would require additional effort and expense.

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Table 1. Vegetational compositon (% of transect by ground coverage) on live-trapping grids on the Snake River BPNA, May 1975.

Grid[a]	Artemisia tridentata	Artemisia arbuscula	Sarcobatus vermiculatus	Atriplex contertifolia	Eurotia lonata	Bromus tectorum	Poa sp.	Lichen	Other species	Bare ground
1					39.2	1.5		0.4		59.0
2				25.0		12.5	6.0			56.4
3	29.7					2.6	2.7	0.6		64.4
4	0.8[c]				76.6	3.1				19.5
5		3.3		12.0[b]						68.7
6			24.9		53.9					21.2
7	20.0[b] 4.6				47.4	11.9	0.5			15.7 15.7
8		13.6		2.1[b] 13.6[c]		0.9	5.9			63.9

[a]See Appendix 2 for grid locations

[b]Thrifty: greater than 50% leaves

[c]Dead or decadent: less than 50% leaves

Table 2a. Results of spring rodent live-trapping (P. maniculatus only) on the Snake River BPNA, 22 March - 25 April, 1975.

Grid No.	Vegetation	North or south of river	Number caught	Home range(ha)	Mean distance moved(m)	Density (animals/ha)	Biomass/ animal(g)	Biomass (kg /ha)
1	Burn (24 June, 1974)	N	7	6.30	62.0	0.37	21.5	0.008*
2	Winterfat	N	6	1.70	64.6	0.68	20.8	0.014*
3	Big sage	N	18	1.36	58.8	3.99	21.0	0.084
4	Cheatgrass	N	2	0.23**	18.8	0.48	19.2	0.009*
5	Shadscale	N	68	1.56	45.3	13.36	20.3	0.271
6	Greasewood	S	18	2.21	47.5	3.09	21.6	0.067
7	Big sage	S	14	1.46	32.1	2.67	22.2	0.059
8	Shadscale/ Low sage	S	3	0.00	0.0	1.10	20.4	0.022*

*$\frac{\text{(Mean weight) (number caught)}}{\text{(estimated sampling area)}}$

**Home range calculated using regression equation (Balph, 1972)

Table 2b. Results of summer rodent live-trapping (*P. maniculatus* only) on the Snake River BPNA, 1 July - 1 August, 1975.

Grid No.	Vegetation	North or south of river	Number caught	Home range(ha)	Mean distance moved(m)	Density (animals/ha)	Biomass/ animal(g)	Biomass (kg /ha)
1	Burn (24 June 1974)	N	26	0.24	47.6	9.88	21.5	0.212
2	Winterfat	N	3	2.04**	67.1	0.31	20.8	0.006*
3	Big sage	N	20	0.21	31.8	8.48	21.0	0.178
4	Cheatgrass	N	3	1.15	49.8	0.41	19.2	0.008*
5	Shadscale	N	16	1.64	54.5	3.25	20.3	0.066
6	Greasewood	S	4	2.11	68.1	0.41	21.6	0.009*
7	Big sage	S	1	0.47**	30.0	0.19	22.2	0.004*
8	Shadscale/ Black sage	S	2	2.53**	75.0	0.18	20.4	0.004*

*$\frac{\text{(Mean weight) (number caught)}}{\text{(est. sampling area)}}$

**Home range calculated using regression equation (Balph, 1972)

Table 2c. Results of fall rodent live-trapping (*P. maniculatus* only) on the Snake River BPNA, 22 September - 4 October, 1975.

Grid No.	Vegetation	North or south of river	Number caught	Home range(ha)	Mean distance moved(m)	Density (animals/ha)	Biomass/ animal(g)	Biomass (kg/ha)
1	Burn (24 June, 1974)	N	6	0.49	52.5	1.14	21.5	0.025
2	Winterfat	N	0	0.00	0.0	0.00	0.0	0.000
3	Big sage	N	9	0.49	37.4	3.19	21.0	0.067
4	Cheatgrass	N	0	0.00	0.0	0.00	0.0	0.000
5	Shadscale	N	No data					
6	Greasewood	S	12	0.91	42.0	2.96	21.6	0.064
7	Big sage	S	0	0.00	0.0	0.00	0.0	0.000
8	Shadscale/ Low sage	S	6	0.00	0.0	2.21	20.4	0.045*

*$\frac{\text{(Mean weight) (number caught)}}{\text{(est. sampling area)}}$

Table 3a. Spring rodent (all species except P. maniculatus) biomass estimates (Kg/ha, obtained from live-trapping on the Snake River BPNA, 22 March-25 April. Numbers in parentheses are animals caught.

Grid	Perognathus parvus	Dipodomys ordii	Dipodomys microps	Eutamius minimus	Onychomys leucogaster	Reithrodontomys megalotis	Ammospermophilus leucurus
1	(5) 0.0622	(4) 0.116	(0)	(0)	(0)	(0)	(0)
2	(0)	(0)	(0)	(0)	(0)	(0)	(0)
3	(2) 0.0013	(0)	(0)	(1) 0.013	(1) 0.004	(0)	(0)
4	(0)	(0)	(0)	(0)	(0)	(0)	(0)
5	(0)	(0)	(0)	(0)	(0)	(0)	(0)
6	(1) 0.0037	(3) 0.0129	(0)	(0)	(0)	(1) 0.005	(0)
7	(1) 0.0125	(0)	(0)	(0)	(0)	(0)	(0)
8	(0)	(0)	(2) 0.003	(0)	(0)	(0)	(0)

Table 3b. Summer rodent (all species except P. maniculatus) biomass estimates (Kg/ha, obtained from live-trapping on the Snake River BPNA, 1 July - August, 1975.

Grid	Perognathus parvus	Dipodomys ordii	Dipodomys microps	Eutamius minimus	Onychomys leucogaster	Reithrodontomys megalotis	Ammospermophilus leucurus
1	(1) 0.006	(4) 0.1710	(0)	(0)	(3) 0.0282	(0)	(0)
2	(0)	(0)	(0)	(0)	(0)	(0)	(0)
3	(1) 0.002	(0)	(0)	(5) 0.0190	(1) 0.0094	(0)	(0)
4	(1) 0.003	(0)	(0)	(0)	(0)	(0)	(0)
5	(0)	(0)	(1) 0.021	(0)	(2) 0.0051	(0)	(0)
6	(0)	(3) 0.0191	(2) 0.041	(0)	(0)	(0)	(0)
7	(0)	(0)	(0)	(0)	(0)	(0)	(0)
8	(0)	(0)	(0)	(0)	(3) 0.0024	(0)	(3) No est.

Table 3c. Fall rodent (all species secpet P. maniculatus) biomass estimated (Kg/ha, obtained from live-trapping on the Snake River BPNA, 22 September - 4 October, 1975.

Grid	Perognathus parvus	Dipodomys ordii	Dipodomys microps	Eutamius minimus	Onychomys leucogaster	Reithrodontomys megalotis	Ammospermophilus leucurus
1	(2) 0.0120	(0)	(0)	(0)	(1) 0.0074	(0)	(0)
2	(0)	(0)	(0)	(0)	(2) 0.0188	(0)	(0)
3	(0)	(0)	(0)	(2) 0.0069	(1) 0.0094	(0)	(0)
4	(0)	(0)	(0)	(0)	(0)	(0)	(0)
5	(0)	(0)	(0)	(0)	(0)	(0)	(0)
6	(0)	(5) 0.0614	(0)	(0)	(0)	(2) 0.0029	(2) No est.
7	(0)	(0)	(0)	(0)	(0)	(0)	(0)
8	(0)	(0)	(2) 0.0413	(0)	(2) 0.0188	(0)	(0)

Table 4. Persistence of deer mice on live-trap grids. Percentages are fractions of original marked cohort.

Grid No.	No. marked spring	No. recap. from spring	No. marked summer	No. recap. from summer	No. marked fall
1	7	1(14.3%)	24	2(8.3%)	3
2	6	0	3	0	0
3	18	4(22.2%)	15	6(40%)	2[a] (11.1%)
4	2	0	3	0	0
5	68	7(10.3%)	10	No data	No data
6	18	0	4	3(75%)	9
7	14	0	1	0	0
8	3	1(33%)	1	0	5[b] (33%)

[a] Two recaptures from spring

[b] One recapture from spring

Table 4. Continued

Dates	Location	Trap-nights CT	WR	JR	Number caught Lc	Sn	Nl	Nc	Mf	Approx. area sampled Acres	ha	Cottontail or jackrabbit numbers with 95% confidence	Biomass/ animal (kg.)	Biomass (lagomorphs/ only) kg /ha
9 June-13 June	Canyon rim	44	35	0	0	0	1	3	0	5	2	None caught		
17 June-27 June	Canyon talus	90	70	0	0	13	0	2	0	5	2	11 (6-17)	0.75	4.125
17 June-27 June	Riparian	90	70	0	0	9	0	4	0	5	2	11 (5-30)	0.75	4.125

Table 5. Results (captures/100 trap nights) of snap-trapping efforts on the Snake River BPNA and surrounding vicinity, 1975.

Site Number[a]	Spring (11 April - 23 May)							Summer (3 July - 15 August)						
	Pm	Pp	Do	Dm	Ol	Rm	Pc	Pm	Pp	Do	Dm	Em	Ol	Pc
1	No Data							37.6		1.3				
2	No Data							5.0	1.0				1.0	
3	No Data							8.6	1.1					
4	No Data							4.4						
5	49.6							11.1					5.6	
6	14.6		3.4					3.3		1.1				
7	6.0	1.0						1.0						
8	4.2							1.2			1.2		1.2	
9	27.6							2.0	2.0					
10	59.4						15.6	40.5						10.8
11	38.5							35.7	1.0					
12	7.5	1.3				2.5		17.4						1.2
13	17.7		1.0					No Data						
14	13.4	3.4		1.1									1.9	
15	7.5	2.2								2.0				
16	9.1				1.1			No Data						
17	7.3		1.2					3.3		4.4				
18	5.4		1.1					1.0						
19	No Data							10.3			1.0			

[a]See Appendix 2 for site locations and descriptions

P.m. - Peromyscus maniculatus
P.c. - Peromyscus crinitus
P.p. - Perognathus parvus
D.o. - Dipodomys ordii
D.m. - Dipodomys microps
E.m. - Eutamius minimus
O.l. - Onychomys leucogaster
R.m. - Reithrodontomys megalotis

Table 5 (Continued)

Site Number[a]	Fall (19 Sept. - 22 Oct) Pm	Pp	Do	Dm	Em	Ol	Pc	Winter (3 December - 12 December, 1975) Pm	Pp	Do	Dm	Rm	Ol	Pc
1	7.4							21.1	1.0	1.0				
2	3.1					1.0		25.8					3.3	
3	4.1				5.2			24.7						
4	1.0	1.0						No Data						
5	No Data							No Data						
6	13.1		1.2					22.2						
7	1.0							6.8						
8	3.3							4.1						
9	No Data							No Data						
10	15.9						3.7	No Data						
11	19.4	5.4						No Data						
12	26.3	4.0										1.3		
13	No Data							No Data						
14	No Data							No Data						
15	No Data							No Data						
16	No Data							No Data						
17	No Data							No Data						
18	3.2		1.1					No Data						

Table 6. Results of lagomorph, woodrat and marmot live-trapping on the Snake River BPNA, 1975.

Dates	Location	Trap-nights CT	WR	JR	Number caught Lc	Sn	Nl	Nc	Mf	Approx. area sampled Acres	ha	Cottontail or jackrabbit numbers with 95% confidence	Biomass/animal (kg)	Biomass (lagomorphs/only) kg/ha
19 Aug.-29 Aug.	Riparian	72	64	0	0	6	0	1	0	5	2	9 (2-24)	0.75	3.375
20 Aug.-29 Aug.	Canyon talus	72	56	0	0	8	0	2	0	5	2	9 (4-19)	0.75	3.375
1 Sept.-5 Sept.	Trio Butte	45	40	0	0	1	0	1	0	5	2	One caught	0.75	0.375**
2 Sept.-11 Sept.	Canyon rim	72	64	0	0	5	6	1	0	5	2	6 (1-21)	0.75	2.25
3 Nov.-14 Nov.	Canyon talus	72	64	0	0	6	0	4	0	5	2	16 (1-312)	0.75	6.00
3 Nov.-14 Nov.	Riparian	82	62	0	0	5	0	1	0	5	2	11 (1-214)	0.75	4.125
4 Dec.-5 Dec.	Canyon rim	36	28	0	0	1*	4	0	0	5	2	One seen	0.75	0.375**
24 Aug.-9 Sept.	Jackrabbit grid	0	0	176	15	1	0	0	0	30	12	33	1.259	2.86

CT = Cottontail trap
WR = Woodrat trap
JR = Jackrabbit trap

Lc = Lepus californicus
Sn = Sylvilagus nutallii
Nl = Neotoma lepida

Nc = Neotoma cinerea
Mf = Marmota flaviventris

*Observed by tracking

**(number of animals) (mean weight) observed

Table 7. Jackrabbit population indices for the Snake River Birds of Prey Study Area, 1972 to 1975.

Year	Season	No. transects	No. jackrabbits observed(n)	Average index(N)	Jackrabbits/ square mile	Jackrabbits/ square km.	Biom. kg/h
1972	Fall [a]	26	9	43.797	160.3	62.6	0.788
1973	Fall [a]	36	6	19.045	69.7	27.2	0.342
1974	Spring [a]	34	4	12.342	45.1	17.6	0.222
1974	Fall [a]	59	9	31.219	114.1	44.6	0.562
1975	Spring	60	7	12.491	45.8	17.9	0.225
1975	Fall	59	11	16.696	61.2	23.9	0.301

[a]Data provided courtesy of Boise District, BLM (Study I)

Table 8. Estimated density and biomass of pheasants on the Snake River BPNA and vicinity, 1975.

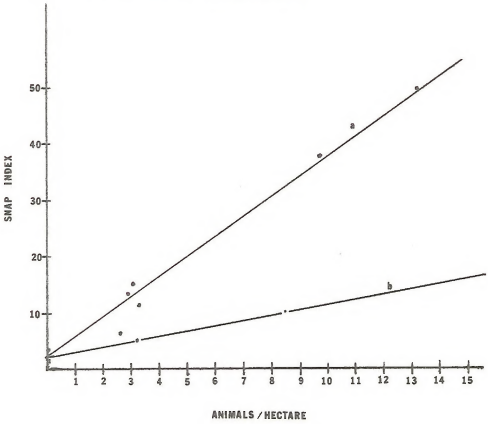
Route	Km.	Total birds seen	Area censused (km^2)	Gates density ($birds/km^2$)	Biomass before breeding season (kg/ha)	Biomass after breeding season (kg/ha)
Melba 1 and 2	44.26	9	8.85	56.3	0.6407	2.2970
Bruneau-Indian Cove	24.30	16	4.86	55.2	0.6282	2.2522
Chattin Hill	17.22	6	3.44	18.0	0.2048	0.7344
Castle	9.82	4	1.96	22.2	0.2526	0.9058
Grandview	13.20	7	2.64	8.2	0.0933	0.3346
Sinker	11.43	1	2.29	33.3*	0.3790*	1.3586*
Flying M	17.22	2	3.44	5.0	0.0569	0.2040

*Note: Only one bird seen. This high estimate is an artifact.

Table 9. Passerine density and biomass estimates, Snake River BPNA, 1975.

GRID		Horned lark		Meadowlark		Brewer's sparrow		Sage sparrow	
		(birds/ha.)	(kg./ha.)	(birds/ha.)	(kg./ha.)	(birds/ha.)	(kg./ha.)	(birds/ha.)	(kg./ha.)
1	Spring		NO DATA				NO DATA		
	Fall		NO DATA				NO DATA		
2	Spring		NO DATA				NO DATA		
	Fall	4.44	0.1239	0	0	0	0	2.22	0.0537
3	Spring	ca. 1	0.0279	ca. 1	0.0959	ca. 1	0.0105	ca. 1	0.0242
	Fall	0	0	0.14	0.0134	0	0	5.55	0.1343
4	Spring		NO DATA				NO DATA		
	Fall	2.22	0.0619	0.42	0.0403	2.22	0.0233	0	0
5	Spring		NO DATA				NO DATA		
	Fall		NO DATA				NO DATA		
6	Spring		NO DATA				NO DATA		
	Fall	11.1	0.3097	2.22	0.2129	0	0	0	0
7	Spring		NO DATA				NO DATA		
	Fall	8.88	0.2478	11.1	1.064	0	0	0	0
8	Spring		NO DATA				NO DATA		
	Fall	4.44	0.1239	0	0	0	0	0	0

Fig. 1. Density relationship for Peromyscus maniculatus.



a. All vegetation types except big sage: $Y = 1.985 + 3.568\ X$ ($r = 0.997$)

b. Big sage alone: $Y = 1.971 + 0.828\ X$ ($r = 0.992$)

Appendix 1. Species names and habitat preferences.

Species	Common Name	Habitat
Peromyscus maniculatus	Deer mouse	Eurytopic
Perognathus parvus	Great Basin pocket mouse	Widespread but prefers bunchgrass
Dipodamys ordii	Ord's kangaroo rat	Sandy soil
Dipodomys microps	Chisel-toothed kangaroo rat	Shadscale
Eutamius minimus	Least chipmunk	Big sage
Reithrodontomys megalotis	Western harvest mouse	Prefers bunchgrass
Peromyscus crinitus	Canyon mouse	Canyon talus
Neotoma lepida	Desert woodrat	Canyon rim
Neotoma cinerea	Bushy-tailed woodrat	Rocky areas, greasewood
Onychomys leucogaster	Northern grasshopper mouse	Big sage, shadscale, winterfat
Mus musculus	House mouse	Near farms, irrigation ditches
Ammospermophilus leucurus	White-tailed antelope squirrel	South side of Snake River
Microtus montanus	Mountain vole	Very close to water in thick grass
Lepus californicus	Black-tailed jackrabbit	Big sage, greasewood, shadscale
Sylvilagus nutallii	Mountain cottontail	Rocky areas, greasewood
Sylvilagus idahoensis	Pygmy cottontail	Dense big sage
Marmota flaviventris	Yellow-bellied marmot	Rocky areas
Phasianus colchicus	Ring-necked pheasant	Farmland, marsh, riparian
Alectoris graeca	Chukar partridge	Rocky areas near water
Sturnella neglecta	Western meadowlark	Big sage, cheatgrass, marsh

Appendix I. Continued

Species	Common Name	Habitat
Eremophila alpestris	Horned lark	Grassy areas
Spizella breweri	Brewer's sparrow	Big sage-grass
Amphispiza belli	Sage sparrow	Big sage
Zenaidura macroura	Mourning dove	Big sage - tall vegetation

Plants:

Artemisia tridentata	Big sage
Artemisia arbuscula	Blacksage
Eurotia lanata	Winterfat
Bromus tectoram	Cheatgrass
Sarcobatus vermiculatus	Greasewood
Atriplex confertifolia	Shadscale

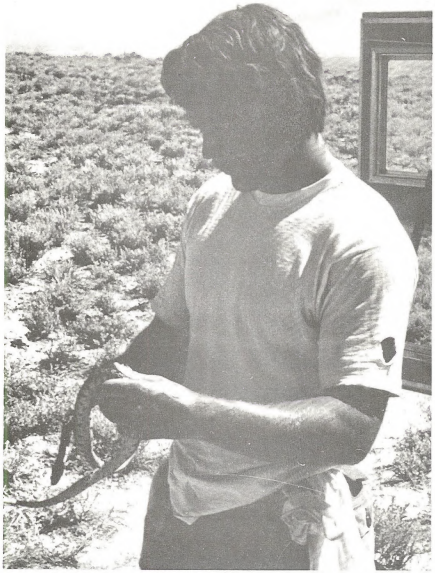
Appendix 2. Locations of rodent and passerine sampling efforts within and in the vicinity of the Snake River BPNA, 1975

Site Number	General Vegetative Description	North or South side of river	Location
1 (Grid 1)	Burn (24 June 1974)	North	T2S R1E Sec. 17
2 (Grid 2)	Winterfat	North	T2S R1E Sec. 7
3 (Grid 3)	Big sage	North	T1S R1W Sec. 24
4 (Grid 4)	Cheatgrass	North	T2S R1E Sec. 14
5 (Grid 5)	Shadscale	North	T3S R1E Sec. 14
6 (Grid 6)	Greasewood	South	T2S R2W Sec. 14
7 (Grid 7)	Big sage	South	T2S R1W Sec. 35
8 (Grid 8)	Shadscale - low sage	South	T4S R1W Sec. 1
9	Old burn-big sage ecotone	North	T1S R1W Sec. 25
10	Canyon talus		T2S R1W Sec. 1
11	Canyon flats		T2S R1W Sec. 1
12	Riparian		T2S R1W Sec. 1
13	Big sage-cheatgrass ecotone	South	T3S R1W Sec. 12
14	Shadscale-big sage ecotone	South	T3S R1W Sec. 28
15	Cheatgrass-big sage ecotone	North	T2S R1E Sec. 23
16	Eurotia-big sage ecotone	North	T2S R1E Sec. 7, 8
17	Greasewood-cheatgrass ecotone	South	T2S R1W Secs. 14, 13, 12
18	Cheatgrass	South	T2S R2W Sec. 11
18	Shadscale-eurotia ecotone	North	T3S R1E Sec. 14, 13

Appendix 3. Biomass values for use in calculations.

Species	Season	N		Mean weight (kg.)	Weighted average (kg.)	Reference
Black-tailed jackrabbit	All year	42		1.259		This study
Cottontail	Spring	20		0.7175		
"	Summer	13	38	0.8038	0.75	This study
"	Fall	5		0.74		
Bushy-tailed woodrat	Spring	8		0.23875		
"	Summer	5	17	0.3344	0.27835	This study
"	Fall	4		0.2875		
Desert woodrat	Spring	1		0.036		
	Summer	4	9	0.118	0.1076	This study
	Fall	4		0.115		
Horned lark		85		0.0279		(Balph, 1972)
Brewer's sparrow		23		0.0105		(Balph, 1972)
Meadowlark		11		0.0959		(Balph, 1972)
Sage sparrow		4		0.0242		(Balph, 1972)
Mourning dove		22		0.1129		(Balph, 1972)
Pheasant		566 ♂		1.380		(Mohler, 1959)
		459 ♀		1.017		(Mohler, 1959)
		Juv.		0.883		(Anderson, 1969)

Rodents - Weights are pooled weighted means for a particular grid over the three seasons. Refer to Tables 1a-f.



Lowell Diller, Research Assistant Study IVa suppliment, holding gopher snake.

ANNUAL REPORT 1975

Study IVaS: Ecology of reptiles in the Snake River Birds of Prey Natural Area

Subcontractor: Department of Biological Sciences, University of Idaho.

Investigators: Donald R. Johnson Major Professor

Lowell Diller- Research assistant

Janice Diller- Field assistant

Project Support: U. S. Department of the Interior, Bureau of Land Management Contract No. 52500-CT5-1003 (To Utah State University).

Objectives:

1. Determine the species composition and biomass of lizards and snakes in specific habitat types within the study area.

2. Determine significant population parameters for these reptile populations including productivity, sex and age ratios, survivorship, and mortality factors.

3. Assess the availability of reptiles as prey for raptorial birds.

4. Determine the impact of reptiles on prey populations utilized by raptorial birds.

5. Determine the effects of habitat alteration on reptile densities.

Annual Summary:

Reptile populations inhabiting the Birds of Prey Natural Area and adjoining lands in southwestern Idaho were studied during a three-month period (late May-late August), 1975. Lizards sighted on transects were recorded during periodic visits in representative habitat types. Mark-release studies of rattlesnakes and lizards were begun on two plots. Specimens of all species were collected off these sites and preserved for analysis.

Plans for Next Season:

Observational censusing of lizards will be continued on existing and newly established transects, including sites south of the Snake River. Mark-release work will be intensified. Efforts will be made to census snake populations in representative habitat types. Snake ingestion rates of prey will be determined for captive and wild-caught individuals.

METHODS

Field work was conducted on the Birds of Prey National Area from late May through late August, 1975. Thirteen transects in six habitat types were censused at least twice during June and July. The area covered was determined by estimating the perpendicular distance from the transect line to an average maximum distance of detection for each lizard species and multiplying this by the distance traversed. The density index for each species was calculated as the maximum number encountered at each site divided by the area censused. Whenever possible the reptiles encountered were captured, weighed and measured to determine age classes and biomass.

Since snakes were not easily censused by this observational method, all snakes encountered in the field, both on and off transects, were captured, weighed and heat branded with a number on the belly scutes for future identification. Rough relative densities for each species are presented as the number encountered in each habitat type. Since search effort varied between habitat types the numbers reported are not strictly comparable.

Two plots were established to conduct mark-release studies: one was established in an area of high western rattlesnake (Cortalus viridis) density and the other where lizards were relatively abundant. All snakes were marked by heat-branding and all lizards captured at these sites were toe-clipped. In addition, snakes and lizards were collected outside these plots and preserved to determine relevant reproductive data.

STUDY AREA

An area on the north side of the Snake River from six miles west of Swan Falls to 12 miles southwest of Swan Falls was most intensely searched this first field season. Habitat types were characterized by the dominant vegetation and the substrate present. At least two transects were established in each of the major habitat types. These were:

1. Winterfat (a): Winterfat (Eurotia lanata) is the dominant plant present while Sandberg's bluegrass (Poa secunda) is also abundant. Scattered patches of big sage (Artemisia tridentata) occur throughout the area. There is considerable open ground due to sheep grazing.

2. Winterfat (b): The vegetation at this site is similar to that of winterfat (a) with a noticeable reduction in grasses.

3. Big sage (a): Vigorous big sage is the most conspicuous species

present. Sandberg's bluegrass and other grasses form a dense ground cover. Winterfat occurs in scattered patches.

4. Big sage (b): The vegetation of this site is similar to that of big sage (a) although patches of winterfat are lacking.

5. Shadscale (a): Shadscale (Atriplex confertifolia) is the most abundant plant present. Patches of winterfat are common. Bud sage (Artemisia spinescens) is scattered throughout the area. There is considerable bareground although Sandberg's bluegrass and cheatgrass (Bromus tectorum) are common.

6. Shadscale (b): Shadscale is again the dominant plant species with a few hop sage (Grayia spinosa) and bud sage plants present. Few grasses occur at this site and thus there is more bare ground than at shadscale (a).

7. Canyon rim (a); This site occupies rocky ground at the edge of a cliff. The most abundant shrubs present are big sage, shadscale, four-winged saltbush (Atriplex canescens), hop sage, and species of rabbitbrush (Chrysothamnus spp.). Cheatgrass is the most abundant grass present.

8. Canyon rim (b): There fewer grasses and more bare ground present at this site than at canyon rim (a). The open areas are hard pan or volcanic cinders.

9. Canyon rim (c): This site is much like canyon rim (b) except the open areas are sandy.

10. Talus slope (a): This site is characterized by a loose boulder, rock and soil surface at the base of a cliff. The amount of cover varies inversely with the amount of rock present. Cheatgrass is the most abundant plant here; there are few scattered shrubs.

11. Talus slope (b): This site is similar to talus slope (a) except that shrubs are lacking.

12. Riparian (a): This site is characterized by a vegetation gradient from the river to xeric locations at greater distances from the bank. The streambank shrubs were not identified. Greasewood (Sarcobatus vermiculatus) is the dominant shrub on the flood plain. Cheatgrass is common. The substrate is sandy.

13. Riparian (b): Similar to (a) except there is more grasses.

The irregularly shaped 2.4 hectare mark-release plot for rattlesnakes was located about six miles southeast of Swan Falls above the canyon rim. It included several rock outcrops. Winterfat dominated the open ground while big sagebrush was the most common shrub on rocky substrates.

The irregularly shaped, 3.2 hectare mark-release plot for lizards was located two miles southeast of Swan Falls above the canyon rim where the substrate was a mosaic of rocky and sandy surfaces. A diversity of shrubby vegetation occurred on the site.

RESULTS AND DISCUSSION

Mean body weights by age class for the more common lizards and snakes of the BPNA are listed in Table 1. Body weights of the less abundant species will be reported later when sample sizes are increased.

The observational census data (Table 2) indicates that the side-blotched lizard (Uta stansburiana) is the most abundant lizard in most habitat types. Because of their larger sizes however the western whiptail (Cnemidophorus tigris) and the leopard lizard (Crotaphytus wislizenii) comprised a greater biomass at most sites. Canyon rim, shadscale and talus slope habitats supported more than twice the biomass of lizards found on winterfat, big sage and riparian sites. The one characteristic these high-density sites held is common was their greater amount of bare ground. Transects within the same habitat type showed similar results.

Because of unequal sampling effort only tentative conclusions can be made regarding the number of snakes collected with respect to habitat type (Table 3). It appears that riparian and canyon rim habitats possess more snakes than the others sampled. The western rattlesnake appears to be about twice as abundant as the second most common snake, the gopher snake (Pituophis melanoleucus).

Preliminary results from the mark-release study provide an estimate of 13.1 rattlesnakes using the Schnabel estimator, a density of 5.5 snakes / ha, probably an average value for rocky habitats. Broad stretches of sandy substrate undoubtedly support smaller numbers.

Preliminary data on size classes, age structure and sex ratios of rattlesnakes appears in Table 4. A sex ratio of 25:16 favored males but the difference is not significant ($P > .05$). Very few immature individuals (one year old) were captured an indication of biased sampling, a heavy mortality within that age group, or, a low

reproductive rate.

Captive rattlesnakes regurgitated Twonsend ground squirrels (Spermophilus townsendi) and a road-killed western rattlesnake contained the remains of a kangaroo rat (Dipodomys sp.). A captive gopher snake regurgitated the remains of a desert cottontail (Sylvilagus nuttalli). The impact of snakes on prey populations utilized by raptors nesting on the BPNA needs further investigation.

Table 1. Mean body weights (g) of BPNA reptiles.

Species	All Age Classes			Adults Only		
	N	Mean	SE	N	Mean	SE
Lizards:						
Cnemidophorus tigris	9	16.1	2.7	6	17.9	0.85
Crotaphytus collaris	9	30.7	3.5	8	32.9	3.2
C. wislizenii	23	23.2	1.6	18	26.6	1.05
Phrynosoma platyrhinos	64	17.3	1.2	31	24.3	1.1
Sceloporus occidentalis	18	15.3	1.2	15	16.9	0.9
Uta stansburiana	31	3.6	0.15	Age classes not separated		
Snakes:						
Crotalus viridis	38	458.1	30.9	36[a]	477.7	29.2
Pituophis melanoleucus	33	212.3	28.0	25[b]	272.7	27.5
Masticophis taeniatus	18	77.2	10.2	16[c]	84.35	10.0

[a] Snout-vent length more than 660 mm

[b] Snout-vent length more than 600 mm

[c] Snout-vent length more than 550 mm

Table 2. Indices of lizard density and biomass. C. t. =Western whiptail (Cnemidophorus tigris); C. w. = leopard lizard (Crotaphytus wislizenii); C. c. = collared lizard (Crotaphytus collaris); U. s. = side-blotched lizard (Uta stansburiana); P. p. = Desert horned lizard (Phrynosoma platyrhinos); S. o. = western fence lizard (Sceloporus occidentalis).

Habitat type (transect)	Species	Density (n /ha)	Biomass (g/ha)	Transect Biomass	$\bar{X}$ Habitat Biomass
Winterfat (a)	C. t.	0.9	20.7		
	C. w.	0.9	16.0		
	U. s.	2.7	9.6	46.3	
Winterfat (b)	C. t.	1.3	23.1		
	C. w.	1.3	29.9		
	U. s.	12.2	43.8	96.7	71.5
Big sage (a)	C. w.	1.9	43.0		
	U. s.	2.8	9.9	52.9	
Big sage (b)	C. t.	1.0	18.4		
	P. p.	1.0	3.7	22.1	37.5
Shadscale (a)	C. t.	1.7	29.7		
	C. w.	1.1	25.7		
	P. p.	0.6	9.6		
	U. s.	11.1	39.6	104.6	
Shadscale (b)	C. t.	9.0	161.3		
	C. w.	0.6	14.9		
	P. p.	1.9	33.5		
	U. s.	14.2	50.7	260.5	182.5
Canyon rim (a)	C. t.	2.8	50.1		
	S. o.	1.9	28.5		
	U. s.	8.4	30.1	108.8	
Canyon rim (b)	C. t.	3.0	53.6		
	C. c.	2.0	61.4		
	P. p.	1.0	17.3		
	S. o.	4.0	61.1		
	U. s.	6.0	21.5	214.9	

continued

Table 2 (continued):

Habitat type (transect)	Species	Density (n/ha)	Biomass (g/ha)	Transect Biomass	$\bar{X}$ Habitat Biomass
Canyon rim (c)	C. t.	2.6	46.3		
	C. c.	0.5	15.9		
	C. w.	1.7	40.1		
	S. o.	3.5	52.7		
	U. s.	3.6	13.0	168.0	163.9
Talus slope (a)	S. o.	9.5	145.4		
	U. s.	11.4	40.6	186.1	
Talus slope (b)	S. o.	8.5	130.2		
	U. s.	6.2	22.2	152.4	169.2
Riparian (a)	C. t.	6.4	115.2	115.2	
Riparian (b)	C. t.	0.6	10.6		
	S. o.	1.8	27.0	37.6	76.4

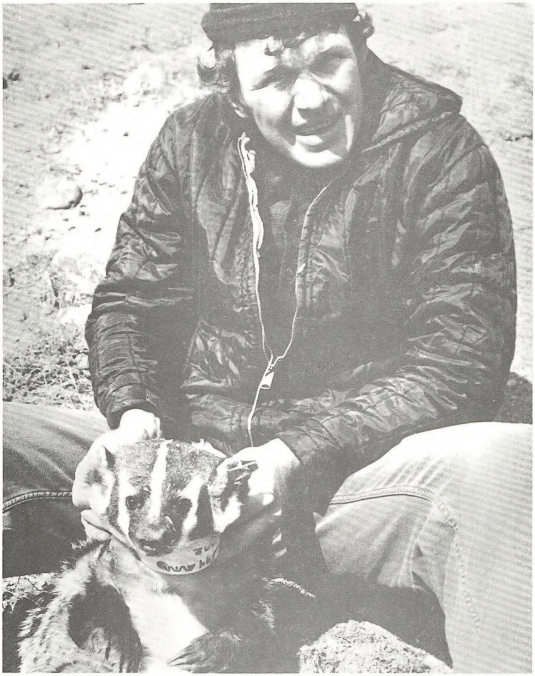
Table 3. Numbers of snakes encountered in relation to habitat and substrate.

Habitat	Substrate	Crotalus viridis	Pituophis melanoleucus	Masticophis taeniatus	Total
Winterfat	loess	3	3	5	11
	rocky	1			1
Big sage	loess	3	10	2	15
	rocky	1			1
Shadscale	loess		1	1	2
	rocky	2	1		3
Winterfat-Big sage	loess	9	1	2	12
	rocky	12		1	13
Grass	loess	2	1	2	5
	rocky	3	2		5
Canyon rim	rocky	13	3	9	25
Talus	rocky	3		2	5
Riparian	mixed	10	14	2	26
Totals		62	36	26	124

Table 4. Size classes, age structure and sex ratios of Crotalus viridis.

Age Classes[1]	Males			Females			Both		
	N	Mean	SE	N	Mean	SE	N	Mean	SE
S-V Length (mm)									
young				3	569	44	3	569	44
subad.	15	805	14	11	745	12	26	780	11
adult	10	948	12	2	908	32	12	942	11
Total	25	862	17	16	732	27	41	811	18
Weight (g)									
young				2	105	43	2	105	43
subad.	13	426	30	10	317	22	23	378	22
adult	11	690	29	2	454	29	13	653	35
Total	24	547	34	14	306	31	38	458	31

[1] young - one year old
subadult- two years old
adult- three or more years old



John Messick, Research Associate Study IVb, with tranquilized badger after attaching radio transmitter collar.

ANNUAL REPORT 1975

Study IV-B: Dynamics of predation upon a raptor prey base in the Snake River Birds of Prey Natural Area, Idaho.

Contractor: Idaho Cooperative Wildlife Research Unit, University of Idaho, Moscow, Idaho 83843.

Investigators: John P. Messick, Research Associate, ICWRU, and Graduate Student, Department of Zoology, The University of British Columbia, Vancouver, Canada V6T 1W5.

Dr. Maurice G. Hornocker, Unit Leader, ICWRU, Principal Investigator.

Dr. I. Mct. Cowan, Professor of Zoology, The University of British Columbia, Academic Advisor.

Jack Whitman, ICWRU, and Lonzo Guilliams, Boise, Idaho, Research Aids.

Project Support: U.S. Bureau of Land Management Contract No. 52500-CT5-1004.

Objectives:

1. Attempt to ascertain the density, sex and age structure, and other population parameters of badgers (Taxidea taxus) on the Snake River Birds of Prey Natural Area, Idaho.

2. Explore the strategy of habitat use and describe the social organization of the badger population.

3. Gather information on the food habits of badgers as an aid to estimating the impact of this predator.

4. Collect information on the food habits of other important carnivores, coyotes (Canis latrans) and bobcats (Lynx rufus).

Annual Summary:

During 1975, 2793 trap days, supplemented by spotlighting and daytime netting, produced 97 captures representing 75 different badgers. Forty-one were males, and 34 were females. At least 8 females were pregnant, lactating, or had given birth in 1975. Twelve were identified as young of the year because their incisors had not completely emerged, or the deciduous canines were being replaced by permanent teeth. Most badgers were taken within a 3 by 5 km area, and the distances between capture and recapture sites were seldom greater than 1.5 km.

Nine badgers were radiotracked, but only four provided substantial information on movement and the utilization of home areas. These animals, two males and two females, restricted most activity to areas of less than 1 km^2. Badgers tended to return to previously used dens.

Forty-two badgers, 28 coyotes, and 2 bobcats were collected as a source of food habits and reproductive data. Fifty-five badger, 43 coyotes, and 3 bobcat scats have been collected as an additional source of food habits information. These samples have not been analyzed, but superficial examination suggests that badgers consume mostly Townsend ground squirrels (Spermophilus townsendii) and, during the summer, scorpions and lizards.

Plans for Next Field Season:

We will continue the procedures initiated during 1975 but make an effort to secure more information on the dispersal of young badgers and sources of mortality. We hope to refine our radiotracking to gain an understanding of the relationships and interactions among members of the badger population. We also hope to secure information on the spatial and temporal patterns of prey-catching and hunting success, in order to quantify the characteristics and intensity of predation by badgers.

METHODS

Capture and Handling Badgers: We trap badgers at their dens and digs with foot traps and immobilize captured animals with ketamine hydrochloride (Ketaset, 100 mg/ml, Bristol Laboratories, Syracuse, N.Y., or Vetalar, 100 mg/ml, Park-Davis, Detroit, MICH), using a syringe fitted to the end of a broom handle. Although individuals vary in their response to the drug, intermuscular injections at the rate of 10 mg ketamine hydrochloride per kilogram of estimated body weight usually produces tractability for 30 min to 1 hour. This agent has a wide margin of safety in badgers, and we sometimes give additional dosages during prolonged handling.

Last summer, we were able to capture badgers at night using an aircraft landing light to pick out their eye shine, netting them, and finally physically subduing the animal prior to immobiliation. Occasionally, badgers can be netted during the daytime.

Weights and body measurements are recorded, and the right ear is tatooed for permanent identification. The left ear is fitted with a numbered ear tag. We are currently using the standard Rototag (Nasco Corp., Modesto, CA) in yellow for males and red for females. In addition, we have experimented with ear streamers, hair dye, and fluorescent paint as an aid to visual recognition of previously captured badgers.

The second, lower right incisor is extracted for subsequent aging by cementum layers. We now also remove a premolar. Animals are dusted with dog or cat flea powder to roust fleas if they are present. Two or 3 ml of blood are withdrawn by syringe from the radial or other vein in the foreleg. Fleas (rarely present) and blood are collected for indirectly assessing the possible occurrence of plague (Yersinia pestis) in the Townsend ground squirrel (Spermophilus townsendii) population. Dr. D. Johnson and W. Melquist, investigators on Study V, discuss the results of this testing in their report.

We confine badgers for 24 hours or more to obtain a scat prior to releasing them at the capture location. Certain individuals are equipped with radio transmitters.

Abundance, Distribution, and Population Parameters: Our trapping and marking program, through capture-recapture technique (Lincoln index or variations of it) and visual sightings, should give data on the abundance, distribution, and population structure.

The assumptions underlying capture-mark-recapture technique of no gain or loss in the population and equal probability of capture are seldom met in field applications. Badgers quickly become trap-wise, but spotlighting and hand captures provide an opportunity to record the ratio of marked versus unmarked animals independent of capture-recapture data obtained through trapping.

Monthly collections of badgers from outside our study area, but in similar habitats, yield information on the reproductive status of females (from copra lutea and placental scars) and breeding condition of males (from testes size).

Radiotracking: We originally proposed radiotracking as the primary tool to gather data on the movements and social organization of badgers. However, technical problems have somewhat limited our success to date.

Shipment of transmitters was delayed some six weeks, and two of this first order eventually proved defective. The fossorial life style of badgers creates problems for the physical attachment of a radio package. Our first collar design was completely unsatisfactory, but T. Dunstan, principal investigator on Study III, has designed a smaller radio which may overcome some of the problems posed by the bulk of the earlier collars.

Food Habits: We document food habits through the examination of scats and stomach samples. Badgers probably leave their scats underground in the wild, but confining captured animals for 24 hours or more, while withholding food, usually results in a fecal sample.

Analysis of scats and stomach samples does not give accurate estimates of the biomass of prey consumed, but extrapolation of data from laboratory feeding trials (Jense 1968) can help overcome this problem.

Emetic drugs (Abdallah and Tye 1967; Radke and Frydendall 1974) and marking prey with dyes or antibiotics (Crier 1970; Evans and Griffith 1973) offer potential for more accurate determination of biomass of prey consumed. These methods are essentially untested in the field. It may prove feasible for us to try these and other ways of assessing food habits and food gathering.

Other Predators: During the first months of this study, it became evident that limitations of funds, time, and capabilities of

the staff would require certain readjustments of the research objectives and scope as originally set forth in the work plan, "Predator-Prey Relationships on the Snake River Birds of Prey Natural Area, Idaho," dated 27 November 1974.

We have devoted our intensive efforts to the badger. Preliminary data suggest that the badger may be the major competitor with the prairie falcon (Falco mexicanus) in predation on Townsend ground squirrels. Furthermore, research on the American badger is meager compared to its European counterpart and other carnivores of similar size and distribution.

Coyotes and bobcats are resident of the area and are of potential importance as competitors for the prey utilized by golden eagles (Aquila chryseatos), red tailed hawks (Buteo jamaicensis), and other large raptors. We currently rely on stomach samples and scats as a source of information on the diet of coyotes and bobcats. It should be possible to extrapolate from other, more intensive, research on these mammals to estimate density and population characteristics.

However, during their inspection of research and management on the Snake River Birds of Prey Natural Area in August, 1975, Dr. R. Olendorff, BLM, Washington, D.C., and Dr. M. Call, BLM, Denver, COLO, emphasized the need to intensify the coyote and bobcat segment of this contract. But they believe that the badger project deserves the full attention of the present researchers and that additional funds and staff are necessary to evaluate the role of coyotes and bobcats.

Therefore, in September we submitted a proposal to the BLM in application for additional funds for the coyote and bobcat segment of this project, and for an extension of the badger work. The BLM has not yet acted on this proposal.

Recording of Data: We make extensive use of form sheets to record information on captures, radiotracking, and other aspects of the project. Locations are recorded as numerical grid coordinates and also plotted on maps. Daily field notes, with a carbon copy, are also made.

RESULTS

Study Area: J. Messick arrived in late December, 1974, and during the first weeks of 1975, he became familiar with the topography and broad patterns of vegetation on potential study sites. In conjunction with other workers, he selected a specific area for most,

but not all, phases of this project. This primary area extends approximately 5 km outward from the northeastern rim of the Snake River Canyon, from south of Swan Falls northward and westward approximately 15 km. This site is flexible, and in actuality we have concentrated our trapping and radiotracking efforts in a smaller area of less than 3 by 5 km. In Fig. 1 this area is indicated by the heaviest density of captures.

Capture and Marking: In Table 1, we summarize the results of our capture and marking efforts during the past year. July was the most productive month, when 400 trap days resulted in 24 captures. Trapping success was lowest during August and the winter.

Spotlighting was only successful during June and July, perhaps because these animals breed during this period and young of the year are moving about. We made daytime captures as badgers were encountered while driving to, from, and around the study area. These methods supplement trapping and provide an independent way of obtaining the ratio of marked versus unmarked animals.

A minimum of eight females was pregnant, lactating, or thought to have bore young during 1975. Certain animals, suspected of being pregnant when captured, were later recaptured while lactating or visually observed with young. This reinforces our confidence in judging whether a female is pregnant.

We identified twelve badgers as young of the year because their incisors had not completely emerged, or their deciduous canines were being replaced by permanent teeth. Perhaps additional animals were young, and we hope that slides of teeth will allow us to confirm or deny this.

Even though locations of captures in Fig. 1 are separated to reflect the density of captures, we have sometimes caught representatives of all age and sex classes within a few meters of each other, or even in the same spot. Such captures were occasionally made within hours of each other. Based on our capture data for 1975, we believe that the density of badgers on our study area is quite high.

In Fig. 2 solid lines connect the locations for badgers captured more than once. The capture and recapture locations for two badgers need explanation. These can be identified in Fig. 2 as the sites separated by the greatest distances.

Male No. 5 was originally captured on 8 March and was subsequently radiotracked until 4 June when J. Whitman caught him a

short distance southeast of the initial capture location. No. 5 escaped from a cage at the BLM trailer overnight on 7 or 8 June. On 16 June, we cornered No. 5 at the corner of Swan Falls Road and Victory Lane. He had moved over 7 km between 7 or 8 June and 16 June and was just over 2 km from the initial trapping site.

Female No. 31 was captured on 3 July, and on 4 July J. Messick released her by mistake nearly 5 km north of the first capture site. J. Whitman recaptured No. 31 on 10 July 2 km north, northwest of the original capture location.

Other workers have provided sightings of marked and unmarked badgers, and these data supplement our recapture information.

Radiotracking: During 1975 we radiotracked nine badgers for varying amounts of time (Table 2). Four of these transmitters operated sufficiently long to provide information on home area and habitat use (Figs. 3-5). Of the other badgers instrumented, the radio apparently failed soon after release on Nos. 7, 3, and 73. The radio on No. 7 was not working when he was recaptured on 9 June. We have not recaptured Nos. 3 or 73.

No. 5 and No. 8 (Fig. 3) were recaptured in June, and the collars removed because of problems presented by the size of the package. The transmitter on No. 5 was also defective.

No. 15 died from unknown causes a few days after she was released with a radio on 1 June.

No. 0 (Fig. 4) was equipped with the collar designed by T. Dunstan. However, she lost her radio on or just before 14 August. We found the transmitter on the surface, but our attempts to recapture No. 0 were futile.

No. 20 (Fig. 5) was recaptured on 10 November. He was fitted with a new transmitter, which failed after 17 November.

J. Messick equipped Female No. 72 with a transmitter on 8 November, and she remained in a den near the capture site until 13 November. She then moved approximately 0.4 km to another den. No further movement or change in the signal occurred, so Messick assumed that she had lost the collar and subsequently evacuated the den. This burrow was shaped somewhat like a spiral staircase, and at 2.3 m it was still going down. The radio was lying at 1.6 m, not far from a ball of what appeared to be nest material, consisting mostly of shredded Artemisia sp.

Badgers Nos. 5, 8, 20, and, to a lesser extent, No. 0 tended to return to previously used dens, although No. 8 was unique in that she used one particular den on 23 different days (Table 2; Figs. 3-5). Since many of these were consecutive days, Messick thought that this was a maternity den. However, when No. 8 was recaptured on 5 June she was not lactating and did not appear to have given birth.

By placing a twig at the entrance we were able to determine if a badger had ventured from a den. Badgers sometimes remained underground two or three days without leaving.

Nos. 5 and 8 were monitored for essentially 24 hours on three and two separate occasions, respectively. However, these were not particularly rewarding in documenting activity patterns. Badger tracks on snow have yielded more information on the pattern of movement. Badgers seem to wander erratically and investigate many ground squirrel and badger holes. They may dig extensively, a little, or not at all at these holes. Sometimes tracks will disappear down a burrow, only to emerge several meters away from another entrance.

Food Habits and Carcass Collections: The scats and stomach samples have not been analyzed, although superficial examination reveals that badgers probably utilize Townsend ground squirrels more than any other prey item. Scorpions and lizards are evident in samples collected during the summer.

During 1975, we acquired carcasses of 42 badgers, 28 coyotes, and 2 bobcats. Fifty-five badger, 43 coyote, and 3 bobcat scats have been collected.

L. Guilliams has been very diligent in helping us make monthly badger and coyote collections. He and others who have trapped in this area for many years believe that coyote numbers are relatively low.

Other Activities: J. Messick left the University of British Columbia prior to the end of the 1974-75 term and completed certain course requirements in absentee.

In January, Messick set up eight, 396 m by 14.9 m transects in various vegetation types (Fig. 6) and counted the number of badger holes in each. Discriminating between very ancient holes and others made more recently was somewhat subjective, but a hole was included in the count if it was open and large enough to accommodate a badger. Results (Table 3) suggest differences in the number of burrows according to vegetation types. This might reflect the intensity of badger hunting

activity, since the vegetation types with the most holes are also those that seem to harbor the highest densities of Townsend ground squirrels.

In November, we participated in a session of the Raptor Research Foundation Meeting devoted to the Snake River Birds of Prey Natural Area.

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Table 1. Numbers and classification of badgers captured by various methods during 1975 on and near the Snake River Birds of Prey Natural Area, Idaho.

Method	♂♂'s	♀♀'s	Recaptures	Total captures/ Recaptures
Trap (2793 trap days)	26	27	15	68
Spotlight (34 nights)	8	5	5	18
Daytime captures	7	2	2	11
Totals	41	34	22	97
				(75 badgers captured 97 times)

Table 2. Summary of badgers radiotracked during 1975 on and near the Snake River Birds of Prey Natural Area, Idaho.

Animal No./Sex	Date instrumented	Last day monitored	Potential days of monitoring	No. days monitored	No. dens used	No. dens reused	Max. No. days of reuse
5 ♂♂	9 Mar	4 Jun	88	70	25	12	12
8 ♀♀	18 Mar	5 Jun	84	74	24	12	23
7 ♂♂	12 Mar	17 Mar	6	6	5	1	2
15 ♀♀	1 Jun	5 Jun	5	5	1	0	--
3 ♀♀	19 Jun	21 Jun	4	4	4	0	--
0 ♀♀	3 Aug	14 Aug	12	12	13	1	2
20 ♂♂	31 Aug	17 Nov	78	52	42	7	6
72 ♀♀	8 Nov	19 Nov	12	11	2	2	5
73 ♂♂	26 Nov	26 Nov	1	1	1	0	--

Table 3. Density of badger holes in 396 m by 14.9 m transects, on and near the Snake River Birds of Prey Natural Area, Idaho.

Transect No.	Predominant vegetation	Holes/ transect	Holes/ hectare
1	Artemisia tridentata	22	13
2	Artemisia tridentata	24	15
3	Eurotia lanata	41	25
4	Atriplex confertifolia	43	26
5	Atriplex confertifolia	60	37
6	Eurotia lanata	58	35
7	Eurotia lanata	64	39
8	Artemisia tridentata	18	10
9	Bromus tectorum	22	13
10	Artemisia tridentata/ Eurotia lanata	56	34

Figure 1. Locations for badger captures and recaptures during 1975 on and near The Snake River Birds of Prey Natural Area, Idaho.

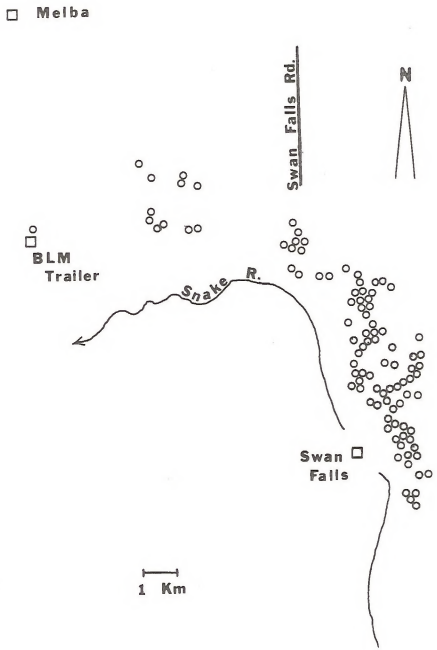


Figure 2. Locations for badgers captured more than once during 1975 on and near The Snake River Birds of Prey Natural Area, Idaho. Lines connect capture sites for individual animals.

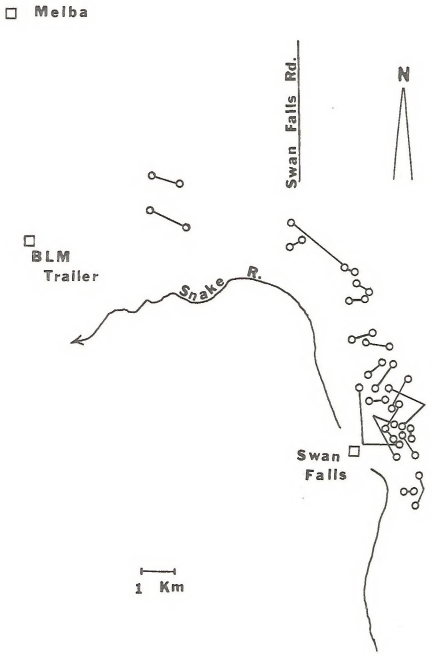


Figure 3. Areas used by male badger No. 5 from 9 Mar. - 4 June, 1975 and female No. 8 from 18 Mar. - 5 June, 1975. Open symbols represent No. 5, and solid symbols represent No. 8.

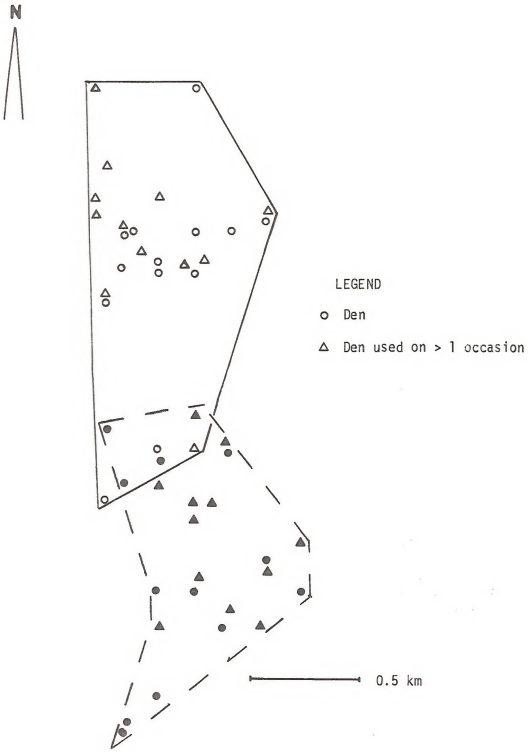


Figure 4. Area used by female badger No. 0 from 3 Aug. - 14 Aug., 1975.

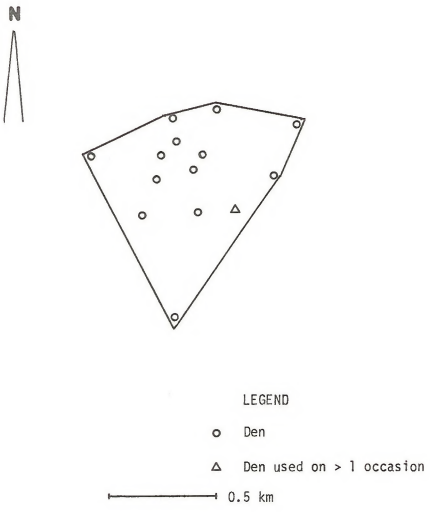


Figure 5. Area used by male badger No. 20 from 31 Aug. - 17 Nov., 1975.

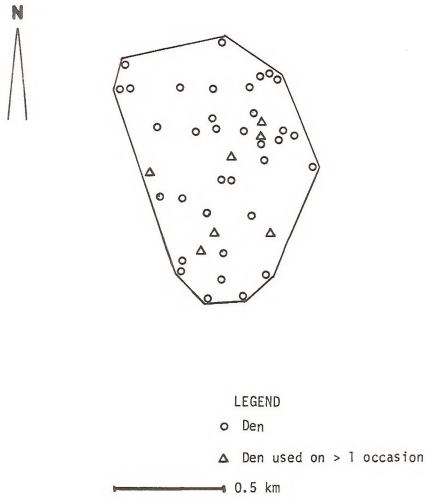
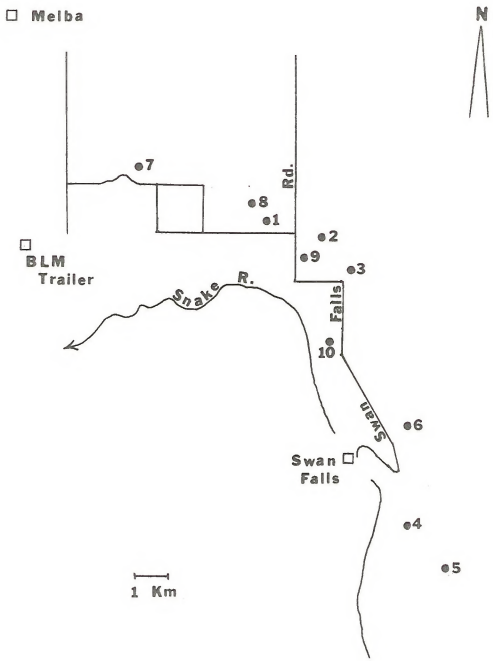


Figure 6. Locations of 396 m by 14.9 m transects used during 1975 to determine the density of badger holes on and near The Snake River Birds of Prey Natural Area, Idaho.



Wayne Melquist, Research Associate Study V, removing Townsend ground squirrel from livetrap.

ANNUAL REPORT 1975

Study V: Population ecology and habitat requirements of Townsend ground squirrels.

Contractor: Department of Biological Sciences, University of Idaho.

Investigators: Donald R. Johnson Principal Investigator

Wayne E. Melquist Research Associate

Project Support: U. S. Department of the Interior, Bureau of Land Management Contract No. 52500-CT5-1002.

Objectives:

1. Describe population parameters of ground squirrel populations including productivity, recruitment, age and sex ratios, and turnover rates.

2. Ascertain population density in a) representative habitat types, b) in relation to land use patterns, and c) in specific foraging areas of several raptors as determined by radiotelemetry.

3. Ascertain food habits and habitat requirements in the major vegetational types.

4. Isolate factors (predation, disease, parasites, etc.) which may limit ground squirrel distribution and density.

Annual Summary:

Populations of Townsend ground squirrels inhabiting the Birds of Prey Natural Area and adjoining lands in southwestern Idaho were studied during a 7-month period (January-July), 1975, as a part of a 4-year study of their ecology and habitat requirements. Body weights, standard measurements, sex and age ratios, density, and productivity were determined at four intensively studied sites. Food habits were determined by stomach analysis. Badger hunting attempts and serum plague titers were determined. Fleas were collected for identification.

Plans for Next Season:

These include a continuation of the trap, mark and release study, the establishment of additional study sites in shadscale and big sagebrush, the monitoring of population parameters, and, the indirect estimation of ground squirrel densities from counts of badger digs in selected habitat types.

INTRODUCTION

Previous research has shown that the Townsend ground squirrel (Spermophilus townsendi) is an important component in the diet of several raptors nesting in the Birds of Prey Natural Area (BPNA). Casting analyses indicate that this squirrel is the major prey item in the diet of prairie falcons (Ogden 1973), red-tailed hawks and ravens (Kochert 1973). Ground squirrels are of less importance in the diet of golden eagles (Beecham 1970; Kochert 1972, 1973).

Recognizing this dietary significance, the Bureau of Land Management has contracted a study of Townsend ground squirrel ecology and habitat requirements on the BPNA. This report summarizes the results of the first field season of that investigation.

STUDY AREA

The study focuses on Townsend ground squirrel populations throughout the BPNA and on adjoining lands, most of which are administered by the Bureau of Land Management. The vegetation types, geological features, climate and land use patterns of the area have been described by Beecham and Kochert (1975).

In early 1975, five intensive study sites of 1 ha (2.47 acres) each were established in representative habitat types on the north side of the Snake River near Swan Falls (Fig. 1). These sites were located in sections 6,7 and 17 of T 2S, R 1 E, Boise Meridian, at locations near nesting pairs of raptors chosen for study by other investigators.

They are:

1. Bedsprings Site. This site is dominated by grasses, primarily cheatgrass (Bromus tectorum) and bluegrass (Poa secunda) (Table 1). The site is used yearly as a campsite by sheepherders during the winter grazing season. It is heavily grazed by sheep.

2. Eurotia Site . This site supports a stand of winterfat (Eurotia lanata) with a fescue (Festuca octoflora) understory. The site is grazed during the winter months by sheep as are all now under study.

3. Comparison Site. This site is dominated by a mixture of shrubs including winterfat, big sagebrush (Artemisia tridentata) and spiny hopsage (Grayia spinosa) with some bluegrass present (Table 1).

4. Burn Site (Section 17). This site was burned during a range fire 24 June 1974. Before the fire its vegetational composition was similar to that of the Comparison Site. Cheatgrass and bluegrass have recovered since the fire (Table 1).

5. Hole-count Site (Section 17). This site was intensely burned during the 1974 range fire providing an opportunity to study its colonization by ground squirrels. It supported little cover in 1975 (Table 1).

METHODS

Field work commenced in January, 1975, to determine early emergence and it was terminated in late July when the last squirrels entered torpor. A telethermometer probe was buried at a depth of 30 cm near the Bedsprings Site on January 27 to monitor soil temperature.

Squirrels were live-trapped with apple as bait, using a minimum of 20 traps at each site. The traps were set in the morning, checked one or more times during the day, and sprung in the evening before leaving. When mid-day temperatures were high the traps were checked more frequently to prevent squirrel mortality. Juveniles were either trapped or snared as they emerged from the natal burrow.

Trapped squirrels were anesthetized with ether, ear-tagged, and toe-clipped for permanent identification. Dye-marking with Nyanzol D proved ineffective as an aid to sight identification. The capture location, body weight, and external reproductive condition were recorded on data cards. Testes position was recorded as either abdominal, inquinal or scrotal. Nipples of females were recorded as not visible, visible through the belly hair, or mammae swollen.

The squirrels were dusted with flea powder and the fleas combed into a pan. Fleas were stored in ethyl alcohol for later identification. Squirrels collected off study sites were necropsied for stomach analyses, litter size based on counts of visible embryos and for testes position. Reproductive tracts were preserved in formalin.

Foraging activities and food preferences were assessed by observations of feeding behavior. Stomach contents were mounted on slides and examined microscopically using techniques described by Johnson and Groepper (1970). Avian predation on squirrels was determined in part by visual observations. Counts of fresh badger digs on the study sites were recorded monthly to determine badger hunting activity.

In cooperation with John Messick (Study IV-b), badger blood samples were collected periodically and the serum airshipped to the Center for Disease Control, Fort Collins, Colorado, for plague (Yersinia pestis) analysis. Plague titers were determined using a passive hemagglutination (HA) technique.

Plant composition and coverage was estimated on a series of 0.25 m^2 circular plots on each of the study sites in late May. Coverage of rock, plant debris, and mosses were included in the bare ground estimates. Forbs of less than 1% coverage were ignored. Total coverage often exceeded 100% because of stratification.

RESULTS AND DISCUSSION

Seasonal Activity Patterns:

Emergence: The earliest evidence of above-ground activity was on January 21. The first squirrel was observed on the Bed Springs Site on 31 January and by the end of the first week of February several squirrels were active at the site. Six squirrels collected between 30 January and 7 February were males, indicating that males emerge first, an observation made earlier by Scheffer (1941) and Alcorn (1940). Females were first trapped on 10 February, suggesting that this is the approximate time of their emergence. The first emergence of probable yearlings (young of 1974) occurred on 21 February. Yearling males emerged with abdominal testes and apparently did not breed. Yearling females did not breed although some adult males in breeding condition were present at the time of their emergence. Young of the year were first observed above ground on 7 April.

Juvenile dispersal: Juveniles continued to suckle periodically after emergence but mammary regression was completed in females nursing young by early May. Juveniles dispersed from natal burrows between 6 and 20 May. The increased activity on the hole-count site at this time suggested that juveniles were colonizing that area (Fig. 2).

Torpor. Based on trapping success, adult males began entering torpor in mid-May. Certain adult males apparently went under in early May for about two weeks, emerged for a few weeks and then made a final entry into torpor. A few adult females went under in mid-May but most did not submerge until the end of that month. A few adults of both sexes were active in early June. Juveniles reduced above-ground activity in late June although one was seen

as late as 21 July. It is likely that juveniles active late in the season are those produced in late litters. The maximum number of days of recorded activity for adult males and females was 110 and 96 respectively. Juveniles are active above ground approximately 90-105 days before entering torpor. In Nevada, males were active about 120 days and females about 135 days between emergence and submergence (Alcorn 1940).

Weather effects on activity: Soil temperature at 30 cm gradually increased from 0 C recorded in early February. During early spring, daytime air temperatures were relatively cool with night-time temperatures below freezing. At that time, ground squirrel activity was greatest at mid-day. As day-time temperature increased, squirrel activity was confined to the cooler morning and evening hours. A few fed at mid-day if shade was available. Captive squirrels died within three hours at 27 C when exposed to direct sunlight.

Inclement weather (snow, rain, wind) reduced above-ground activity. Squirrels active in strong winds (40 kmh or more) moved about cautiously and frequently retreated to burrows. On clear, cold days squirrels were seen sunning themselves in protected sites.

The activity of an adult female was recorded from its time of emergence at 0943 hours until it submerged for the night at 1730 hours on a harsh windy spring day during which it rained and snowed. Upon emergence the squirrel moved about nervously and retreated to its burrow after 5 minutes. Three hours later it emerged again for 4 minutes. At 1423 hours she began feeding periodically above ground until final submergence. A total of 91 minutes were spent above ground with 80 minutes spent in feeding. During this time she moved no more than 30 m from the burrow, about one-half the normal foraging distance during favorable weather.

Movements: Local movements appeared greatest during the breeding season. One adult male was observed pursuing another squirrel for about 200 m. On 1 March, the movements of an adult male were monitored throughout the day. It confined its activity to an elliptical area approximately 130 by 70 m. Its den was located at one focus of the ellipse. The time of emergence of a female was observed on 16 days and that of submergence on 14 days. This information was also noted occasionally for an adult male. In both cases the sleeping burrow was located at one end of the activity area. The female confined her activities to an elliptical area of about 60 by 35 m.

Territorial behavior was infrequently observed. A female chased

some, but not all, squirrels away from her burrow entrance. Moreover, several squirrels of both sexes have been observed entering the same burrow system with no indications of aggressive behavior.

Reproductive Parameters:

Breeding and Sexual Development: Adult males emerged in early spring in breeding condition (testes scrotal). Breeding took place shortly after females emerged in early February. The breeding season lasted about three weeks. Copulation likely occurs underground as it was never observed.

On 1 March, during a nine-hour period, an adult male was observed "coaxing" three smaller squirrels believed to be females, into a burrow where they may have been bred.

Some testicular regression occurs by the end of February. By the second week of March, all males had either inguinal or abdominal testes. Testis length and width of breeding males was 14 and 9 mm respectively (n = 7). These measurements for 10 nonbreeding males were 7 and 4 mm and for juvenile males 5.2 and 2.75 mm (n = 8).

Adult females sacrificed on 24 February had developing embryos. Nipples of gravid females began enlarging and were visible through the belly hair by early March. Based on embryo size, changes in body weight and mammary development, parturition began the second week of March and extended through the fourth week. The first young were observed above ground on 7 April.

Productivity: Reproductive tracts were obtained from 26 females during the spring. Litter size based on counts of visible embryos averaged 6.9 (n = 11). Scheffer (1941) obtained an average embryo count of 8.6 (n = 52) in southcentral Washington. Counts of placental scars from 15 uteri averaged 7.5. One case each of resorption and ecotopic pregnancy were noted. Mean litter size based on embryo and placental scar counts for Spermophilus townsendi idahoensis was 7.2. Two reproductive tracts from S. t. mollis, the subspecies found south of the Snake River, had 12 and 13 placental scars, suggesting a higher birth rate in that subspecies. In Nevada, Alcorn (1940) found mean embryo counts for mollis of 10 (n = 17) in 1937, 10 (n = 98) in 1938 and 8 (n = 48) in 1939.

These populations have one litter per year. Litter size at emergence ranged from three to seven young (mean c.5). Since placental scar counts indicate a higher birth rate, some mortality occurs between

parturition and emergence. Svihla (1939) reported that litter size in captives ranged from one to ten (mean 4.75; n = 12). He found that females killed some of the young or abandoned them. It is not known if this occurs in the wild.

Growth and development: A total of 542 body weights was obtained from ground squirrels trapped at four sites during 1975 (Table 2). Adult males emerged with significant amounts of body fat but fat reserves of emerging females were largely depleted. Yearlings appeared quite thin at emergence. Adult males lost weight during the breeding season and then made a steady weight gain prior to torpor. Adult females gained weight rapidly due to embryo enlargement and in March their mean weight nearly equalled that of adult males. Females showed little weight gain in April probably because of the energy demands of lactation. Large weight gains occurred following weaning of the young. Obese squirrels just prior to torpor fed lethargically. The heaviest adult male weighed 352 g and most adult males weighed more than 300 g. The heaviest female, which lost her litter shortly after parturition and hence avoided lactation, weighed 268 g. Most females weighed 200-250 g just before torpor. The average weight of males was consistently greater than that of females.

Juveniles grew rapidly from an average of 39 g at emergence in early April to 279 g for a male and 211 g for a female shortly before submergence. Most young males weighed about 200 g just before torpor, while females averaged somewhat less. Juvenile and adult males remained easily distinguishable but juvenile females were less easily recognized from adult females late in the activity season.

Total length, tail, hind foot and ear lengths were recorded from 34 sacrificed squirrels (Table 3). Males exceeded females in all measurements except ear length.

Population Parameters:

Age and sex ratios: During the 1975 field season (late January to mid-July) a total of 246 ground squirrels were ear-tagged and toe-clipped on the four trapping sites (Table 4). Although the overall sex ratio was balanced, that of juveniles favored males (60%) while that of older age classes favored females (57%), evidence of higher mortality in males. These data may not accurately reflect sex ratios among residents since they include squirrels which later dispersed. An adult and yearling male from the Bedspring Site for example,

ear-tagged early in the season, were recaptured on April 12 about 100 m northwest of the site where they had apparently taken up residence.

Density: Although traditionally known as a colonial species, Townsend ground squirrels are found throughout most of the BPNA north of the Snake River. Yet densities varied at the sites studied: (Table 5) probably because of food, cover and soil texture differences.

Population estimates for each site were determined by recording (1) the number of squirrels trapped at least twice, (2) the location of the captures, and (3) the time elasping between first and last captures during the activity period.

The number of squirrels present on a site fluctuated throughout the activity season because of dispersal, recruitment and mortality. Density estimates were determined for the populations prior to emergence of the young and again at the end of the activity season (Table 5). The densities are reported as both the minimum and maximum likely present. Since juvenile dispersal continued after adult submergence, the density of resident adults had little effect on the number of young entering torpor on the site. Competition among juveniles for burrow sites may have influenced the number of juveniles over-wintering on an area.

Recruitment: Counts of successful litter production were used to estimate the number of young produced on each site (Table 6). In every instance these estimates exceeded density estimates of juveniles based on trapping (Table 5), confirming the effects of dispersal, predation and probable cannibalism on the number of juveniles present.

Food habits:

Bait preference: Several baits were tested including lettuce, cracked corn, rolled oats, whole wheat, commercial rabbit pellets, ground squirrel flesh and apple. Apple proved to be the most successful bait and it was used continuously throughout the field season. Several squirrels were retrapped more than 15 times, some as often as three or more times daily. Some trap avoidance was also noted however. Balph (1968) found that Uinta ground squirrels (Spermophilus armatus) had equal probability of capture in either baited or unbaited traps (n = 51).

Field observations: Ground squirrels avidly ingested the fresh growth of cheatgrass early in the season. This introduced winter

annual has invaded vast areas of southern Idaho where the native vegetation has been disturbed by heavy grazing or fire (Stewart and Hall 1939).

On 19 February the reaction of a ground squirrel to raw flesh was observed. The carcass of a freshly-killed squirrel placed at a burrow entrance was fed upon by the burrow occupant and squirrels were frequently seen feeding upon squirrels killed by vehicles.

Squirrels living near grain fields appear to forage heavily on crop plants. They are often seen crossing roads between their burrows and the fields, sometimes carrying a portion of the stem in their mouths.

Other than during the breeding season, ground squirrels spend most of their time above ground feeding. During a period of about four months their weight doubles. They ingest a prodigious amount of food for their size. The stomachs and intestines, together with their contents made up from 15.5 to 39.4 % (mean 30%) of the total body weight of 42 ground squirrels. If avian predators discard these parts a serious error could be introduced in basing prey biomass estimates on total body weight of ground squirrels.

Stomach content analysis: The volume estimates of food items in the stomachs of 77 ground squirrels are summarized in Table 7. The above-ground parts of grasses comprised a significant part of the diet in all habitats, particularly in late winter and early spring. Because of its abundance, we believe that most of the grass ingested was Bromus tectorum. With the onset of spring growth in forbs and shrubs, the use of grass decreased. Winterfat leaves are an important dietary component during the spring and summer. Its use seems directly proportional to its availability. Winterfat leaves made up 58% of the food ingested on sites where that species was dominant. The use of insects was minor although insects comprised a large part of the stomach contents of a few squirrels collected in shadscale-hopsage habitats south of the Snake River. Further collecting in these habitats is planned next season.

Habitat requirements:

Soil depth and texture, as well as land use practices, influence ground squirrel density and distribution. Shallow soils near the canyon rim support few ground squirrels. Deeper loess at the four study sites supports larger numbers. Burrows are easily dug in these soils. Tunnel depth averaged 1.5 m in the two burrow systems excavated.

Both of these penetrated the caliche layer about 15 cm thick. Ground squirrels are less abundant in coarser soils or at sites with rocky surfaces.

Ground squirrels occupied recently established grain fields along the Swan Falls Road both before and after harvest. Squirrels living in fallow fields apparently obtained food from nearby undisturbed sites. Squirrels were absent in other agricultural areas, such as the vicinity of the Swan Fall-Victory Lane intersection where land has been under cultivation for about 10 years. Squirrels living in uncultivated land adjacent to this area were frequently seen along the edges of fields feeding on young succulent plants.

Distribution in Idaho:

Four subspecies of Spermophilus townsendi are found in Idaho including vigilis, idahoensis, artemesiae and mollis (Larrison 1967). Two of these (idahoensis and mollis) inhabit parts of the BPNA, while all four are probably found within the larger boundaries of the intensive raptor study area. The Snake River forms a natural barrier separating idahoensis and artemesiae on the north from mollis and vigilis on the south. S. t. idahoensis is well distributed at relatively high densities on the BPNA while mollis appears to have a limited distribution within the area south of the Snake River. Davis (1939) describes its western limits as Murphy and our observations seem to confirm this. According to Davis (1939) the eastern limits of vigilis lie near Marsing where its supposedly intergrades with mollis. North of the Snake River idahoensis extends east to the vicinity of Bliss where it apparently intergrades with artemesiae (Davis 1939). Populations of idahoensis appear much reduced in density along the eastern border of its range.

Mortality factors:

Predation: Several instances of prairie falcons capturing ground squirrels have been observed on the study area. A golden eagle was observed flying from the ground with what appeared to be a ground squirrel. Red-tailed hawks have been observed flying to the canyon with ground squirrels in their talons. In addition to these raptors, ravens have been observed capturing squirrels on numerous occasions. On 15 May, four ground squirrels, apparently juveniles, were taken by ravens in the vicinity of the Bedsprings Site.

On 24 February, a suspected yearling squirrel (80 g) was killed by a much larger squirrel and later recovered before it was dragged down a burrow entrance. On 22 April, the hind leg of a juvenile

ground squirrel was found near the burrow entrance of a female with a litter, suggesting possible cannibalism of litter mates. Alcorn (1940) observed adult males killing and feeding on young ground squirrels.

Badgers are efficient ground squirrel predators. On 11 April and on 3 June badger digs were observed on the Bedspring Site where a badger had plugged several escape holes around burrow entrances which it had excavated. Juvenile squirrels are most vulnerable to predation before they emerge and for a few weeks afterward. They show little or no fear of predators during this period. On the Bedspring Site badgers are known to have eliminated two litters before the young squirrels appeared above ground and two litters after emergence. As a result badgers eliminated four of the six litters produced on the site in 1975. In addition badgers took several members of the surviving litters a few weeks after emergence. Badger predation was apparently less successful on the other study sites.

Badger digs were recorded on the five study sites monthly beginning in March, 1975 (Table 8), a total of 250 capture attempts. There was a significant positive relationship between fresh badger digs and squirrel density (regression coefficient (b) = 0.91; n = 5) which can be expressed by the linear relationship $\hat{Y}$ (estimated badger digs) = 3.41 + 0.91 x (ground squirrel density, N/ha).

Disease and parasites: Trapped ground squirrels frequently were infested with lice, ticks, mites and fleas. Several squirrels harbored as many as 75 fleas, specimens of which have been sent to Dr. V. J. Tipton, Brigham Young University, for identification.

Rodent or bubonic plague is an epizootic disease caused by the bacillus Yersinia pestis. In Utah, Townsend ground squirrels were relatively abundant prior to 1937 when they were decimated, probably by plague (Hansen 1956). Svihla (1939) reported a die-off of Townsend ground squirrels in Washington about the same time. No decimations of the ground squirrel populations on the BPNA have been reported.

Serological monitoring of predators is useful in detecting the presence of plague in prey populations (Fitzgerald, In press), since the predators develop antibodies following exposure. Antibody titers at levels of 1:32 or greater are considered evidence of past exposure. Twenty of 22 samples of badger sera met or exceeded this level (Table 9). The wide range of titers encountered (none to 1:2048) suggests sporadic plague exposure by both adult and juvenile badgers. An adult male trapped on 6 June, 30 August and 10 November had HA titers of 1:512, 1:128 and 1:64 respectively, an indication of a progressive decline

in titer following exposure. We believe that outbreaks of plague have occurred in ground squirrel populations of southwestern Idaho in the past and that they could occur there in the future.

Other sciurids:

A population of Belding ground squirrels (Spermophilus beldingi) is located in an agricultural area on the south side of the Snake River near Walter's Ferry. Durrant and Hansen (1954) found this species in meadows in Jerome County east of the BPNA and Townsend ground squirrels on upland drier soils nearby. When the latter species was absent, Belding ground squirrels were also found on drier sites. Hall (1946) found a similar situation in Nevada populations of these species. Durrant and Hansen (1954) concluded that Townsend ground squirrels displace other species on drier sites in the Intermountain Region.

We have observed small numbers of antelope ground squirrels (Ammospermophilus) on the south side of the Snake River from Poison Creek to Walter's Ferry. Their distribution appears quite irregular. In California, a closely related species A. nelsoni utilized burrow systems of kangaroo rats almost exclusively rather than building any of their own (Hawbecker 1953). A similar situation may exist on the BPNA with respect to kangaroo rats and antelope ground squirrels. Soil characteristics and competition from Townsend ground squirrels may also affect the distribution and density of this species in southwestern Idaho. Because of its low densities and sporadic distribution, antelope ground squirrels are probably not an important item in the diet of raptors of this region.

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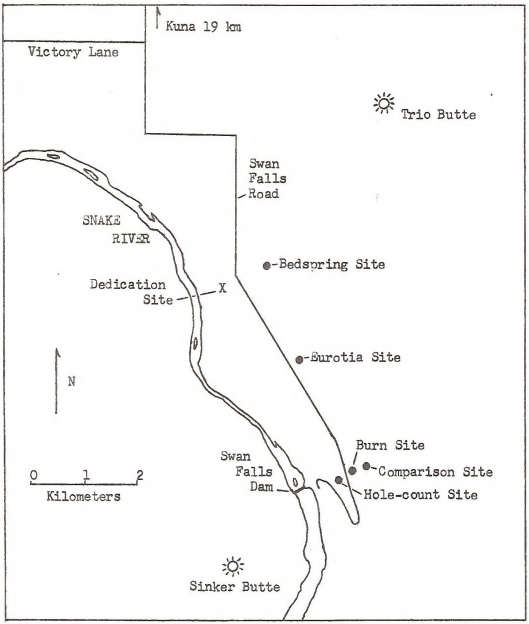

Fig. 1. Location of intensive study sites in the Snake River Birds of Prey Natural Area.

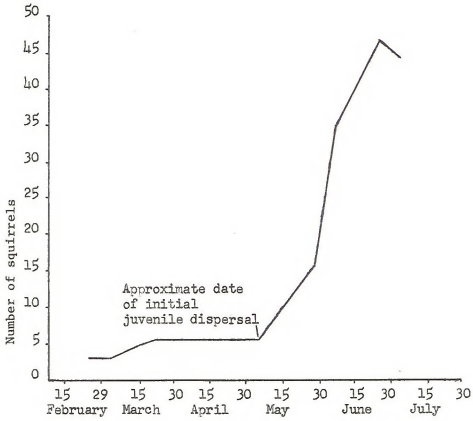

Fig. 2. Townsend ground squirrel activity measured by holes dug on the one-hectare hole-count site. One hole equals all holes dug within a five meter radius of a central hole.

Table 1. Plant coverage (%) on intensive study sites, 23 May 1975. Frequency in parentheses.

	Site				
	Bedspring	Burn	Comparison	Eurotia	Hole count
Shrubs					
Eurotia lanata	< 1 (6)	< 1 (4)	9.8 (40)	14.5 (98)	
Artemisia tridentata			5.4 (30)		
Grayia spinosa			2.8 (10)		
Forbs					
Desurainia pinnata	< 1 (12)	< 1 (8)	1.1 (68)	< 1 (12)	
Sisymbrium altissimum	1.9 (12)				
Grasses					
Bromus tectorum	60.2 (92)	4.0 (68)	< 1 (20)	1.5 (54)	11.5 (70)
Sitanion hystrix		< 1 (14)	< 1 (24)	< 1 (16)	< 1 (6)
Festuca octoflora			< 1 (2)	20.3 (100)	
Poa secunda	4.6 (14)	5.8 (76)	3.4 (70)	3.2 (84)	< 1 (8)
Bare ground	35.2 (96)	89.4 (100)	81.2 (100)	61.1 (100)	87.4 (100)

* Burned 24 June 1974

Table 2. Average weight (g) of ground squirrels. Range in parentheses.

Month/Sex	N	Yearling/Adult	N	Juvenile
February				
Male	38	162 (80-202)		
Female	46	116 (65-163)		
March				
Male	61	172 (97-246)		
Female	82	157 (66-220)		
April				
Male	22	210 (148-285)	21	79 (39-127)
Female	69	166 (114-248)	22	76 (41-124)
May				
Male	14	275 (205-334)	41	144 (84-225)
Female	27	202 (138-268)	24	126 (63-180)
June				
Male	9	296 (264-352)	47	198 (136-279)
Female	0		19	164 (106-211)

Table 3. Body measurements of adults. Sample size in parentheses.

Sex	Total length	Tail	Hind foot	Ear
Males (18)	224 mm	50 mm	36 mm	8 mm
Females (16)	213 mm	47 mm	34 mm	8 mm
Both (34)	219 mm	49 mm	35 mm	8 mm

Table 4. Sex and age of ear-tagged ground squirrels. Percent in parentheses.

Site/Sex	Yearling/Adult	Juvenile	Total
Bedspring			
Male	28	30	58 (53)
Female	43	9	52 (47)
Burn			
Male	9	18	27 (46.5)
Female	7	24	31 (53.5)
Comparison			
Male	11	2	13 (46)
Female	12	3	15 (54)
Eurotia			
Male	13	12	25 (50)
Female	19	6	25 (50)
Total			
Male	61 (43)	62 (60)	123 (50)
Female	81 (57)	42 (40)	123 (50)

Table 5. Estimated population density (n/ha) at four sites.

Age/Sex	Bedspring	Burn	Comparison	Eurotia
Yearling/Adult				
Male	5-8	3-4	4-7	4-4
Female	10-17	3-9	3-4	3-3
Juvenile				
Male	4-6	2-4	1-1	2-2
Female	1-2	4-9	1-2	2-2
Total	20-33	12-26	9-14	11-11

Table 6. Estimated number of young produced on study sites, assuming an average of five emerging/litter.

Site	Number of Litters	Estimated no. produced
Bedspring	4*	20
Burn	8	40
Comparison	4	20
Eurotia	3	15

* At least two additional litters lost to badgers before emergence.

Table 7. Estimated volume (%) of food items in stomach contents. T = trace, less than 1%.

ADULTS	Grass		Other	Winterfat	
Site/Month(s)	Seed	Leaf/stem	leaf	leaf	Insect
Burn (Jan-Feb)	3	97			
Winterfat (Feb-Mar)		92	6	T	1
(Apr-May)		31	10	58	1
Brome (Feb-Mar)		85	12	3	
(Apr-May)		40	20	25	15
Big sage-cultivated					
(Apr-May)		64	31	3	2
Big sage-winterfat					
(Feb-Mar)	T	94	5	T	T
Apr-May)		46	11	40	1
JUVENILES					
Big sage-winterfat					
(Apr-May)	13	54	9	19	5
(Jun)	23	23	33	17	3
Cultivated (Jun)	10	48	42		T

Table 8. Badger hunting attempts at five study sites. One attempt may include more than one dig. % in parentheses.

Month	Bedspring	Burn	Comparison	Eurotia	Hole count	Total
March	4	0	0	1	0	5
April	5	2	3	2	0	12
May	11	2	0	4	0	17
June	5	10	9	2	0	26
July	32	12	5	6	2	57
August	15	16	6	3	0	40
September	3	15	2	5	0	25
October	18	5	10	5	1	39
November	7	7	0	4	4	22
December	1	0	1	5	0	7
Total attempts	101	69	36	37	7	250
Ear-tagged squirrels	110	58	28	50	10*	

*Not trapped; estimated from hole counts.

Table 9. Agglutination titers of *Yersinia pestis* in blood samples[1] from badgers.

Sex/Age[2]	Negative	1/32	1/64	1/128	1/256	1/512	1/1024	1/2048
Adult								
Male	1	1	1	2	1	3	1	
Female	1		1	1		1	2	1
Immature								
Male			1	2				
Female					1	1		
Totals	2	1	3	5	2	5	3	1

[1] Collected by John Messick, Study IV-b.

[2] Age estimates subject to revision.

ANNUAL REPORT 1975

Study VII: Raptor Nesting and Feeding Behavior in the Snake River Birds of Prey Natural Area, Idaho

Contractor: Department of Wildlife Resources, University of Idaho

Investigators: Steven R. Peterson, Principal Investigator
Gayle M. Sitter, Graduate Assistant

Project Support: U.S. Department of the Interior, Bureau of Land Management Contract No. 52500-CT5-1064

Objectives:

1. To observe during daylight hours one pair each of golden eagles (*Aquila chrysaetos*) and red-tailed hawks (*Buteo jamaicensis*), and two pairs of prairie falcons (*Falco mexicanus*) for the purpose of recording feeding visits, behavior of the adults and young, and social interactions.
2. To operate the Bureau of Land Management's (BLM) radio-controlled time-lapse movie units at the nests.

Annual Summary:

Due to nest failure and bird activity, the above objectives were changed as the season progressed. One eagle nest was abandoned as soon as the study began, and bird activity at an alternate eagle nest was greatly altered when the camera was installed. The red-tailed hawk nest was found to be inaccessible for repeated checking of camera recordings. Therefore, most of the field season was spent observing the feeding behavior as well as the inter- and intra-specific relations among prairie falcons. Incidental information on red-tailed hawks and eagles was recorded when possible.

Observations from this year's work showed that food-caching is prevalent in prairie falcons. Frequency of the caching process and reuse of cached items were higher than previously known.

Behavioral responses concerning inter- and intraspecific aggression were recorded. Adult aggression toward alien young was high and may contribute to some juvenile mortality.

Starvation of fledged young may be an important mortality factor.

Prey analysis has not been completed at this time. These data will be reported later.

Plans For Next Field Season:

Feeding habits and prey consumption will be studied using remote-controlled cameras, direct observation, and pellet collection. Total consumption and wastage will be estimated and the use of prey caches will be noted.

We plan to examine the relationship between nesting density and cliff relief. Defended territories will be mapped and compared in areas of different cliff structures.

Post-fledging mortality will be investigated using tail-sutured radio packages to follow movements of young birds after fledging. Dead birds will be collected and autopsied to provide clues to post-fledging mortality in juveniles.

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METHODS

From 12-18 May 1975, an eagle nest containing a remote-controlled camera was observed at the "Rapids" location. The pair did not go near the nest as long as the camera was in place. Two days after the camera was removed, the adults returned to the nest. Attempts to record the food habits of this pair of eagles with remote-controlled cameras were discontinued for fear of causing the adults to abandon the young. The nest was observed with binoculars until the birds had apparently returned to a normal brooding routine.

Intensive observations of prairie falcons were started on 19 May. Two scrapes were located, and a camera was installed in one of these scrapes on 21 May. These scrapes were in close proximity to scrapes monitored by Study III. Dawn-to-dusk studies of prairie falcon feeding behavior was started on 21 May and continued until 15 June. By the middle of June, all prairie falcon young had fledged.

After 15 June, observations were recorded only during 8 hours of the day. These 8-hour observation periods continued until 10 July, when most prairie falcons had left the study area. Emphasis during this period was on recording intra- and interspecific social actions.

RESULTS AND DISCUSSION

Food Caching:

Observations of feeding visits established that prairie falcons cache prey outside the scrape. This phenomenon was first noted in a suspected nonbreeding pair on 27 May. The male came over the rim of the canyon with a large ground squirrel (*Spermophilus townsendii*) and exchanged it with a female. The female then flew to a perch and proceeded to feed on the carcass. After she had finished feeding, she flew with the remaining portion of the prey to a very broken area of the cliff. The partially eaten prey was then placed behind a rock. Subsequent observation verified that cached prey items are placed in specific localities for reuse and not dropped at random within the territory.

After the initial caching observation, more attention was directed at observing prairie falcon feeding behavior to determine the frequency of caching. Whenever prairie falcons flew or perched near cache areas, they were observed closely. Throughout the field season, we were able to document several instances of prey-caching.

Three categories of food cache use were observed: (1) prey items brought from a cache to the scrape; (2) prey fed on at the scrape, then deposited in a cache; and (3) direct deposition of prey in a cache without prior utilization at the scrape. The data do not indicate a relationship between time of day and category of cache use although feeding visits to the scrape appear to be concentrated in the morning and afternoon (Fig. 1).

Between 3 and 6 June, 19 feeding visits were recorded at the nest with the camera. Nine of these visits utilized a food cache either before or after feeding. Food-caching was recorded in 3 different pairs of prairie falcons on the study area, and another food cache was found by John Doremus (personal communication) in an additional part of the Birds of Prey Natural Area.

The number of feeding visits parents made to the scrape was recorded. In a scrape with two young, 84 trips with prey were recorded, for an average of 4.0 ± 0.5 trips per day.

Disposal of chicks that die in a scrape may be related to prey-caching. On 23 July, an investigation of cache areas revealed no apparent food items, but a dead prairie falcon chick was recorded. The chick was badly deteriorated, but appeared to be one day old at death. The dead chick had been placed in a rock crevice about 220 mm wide, similar to how prey items were cached. This ledge was not large enough for a scrape nor was it near any other scrape. Prey

items deposited in a cache were normally butchered by the bird (digestive tract removed), but the dead chick was intact. This suggests the chick died in a scrape and was later deposited in a cache without being butchered.

Our data suggest that prey-caching may be a normal behavior pattern in prairie falcons rather than the unique behavior of one pair. Food caches may be used more often during the latter part of the nesting season than when the nestlings are very young. A cache may also be used for disposal of young chicks that die in the scrape.

Adult-Adult Aggressions in Prairie Falcons:

When we arrived on the study area on 25 April, prairie falcons had already established their territories. Aggressive behavior between individuals of adjoining territories was not apparent as prairie falcons flying along the cliff would turn at adjoining territory boundaries and adjacent birds would not intercept intruders unless the bird was definitely inside the other bird's territory.

Territories did not appear to extend more than 32 m from the cliff base. All confrontations between adults were within this distance. When confrontations did occur, they seldom lasted more than a few seconds. After the initial response by the defending bird, the intruder rolled, displayed talons, and then departed from the area.

On 14 June, members of Study III released a radio-tagged adult prairie falcon in a territory of another prairie falcon. A confrontation occurred immediately, and strong aggressive behavior was exhibited by the defender until the radioed bird was out of the territory.

Territorialism seemed to be stimulated during periods of excitement. Once, when we were working near a scrape, the resident male attacked another prairie falcon that was outside his normally defended territory. In this incident, the territory seemed to be extended much further than normal, as the "intruder" was actually out over the desert and not near the scrape nor within 32 m of the canyon rim. On several other occasions when birds were excited by human disturbance, territorial aggressions appeared more intense.

Occasionally, other prairie falcons were tolerated within the territory. In one instance, a suspected nonbreeding pair was tolerated within the territory of a breeding pair. No aggressive behavior was directed towards these suspected nonbreeders even when they perched near the occupied scrape. On four occasions, the breeding male that occupied the observed scrape copulated with the nonbreeding female.

As the season progressed, territories appeared to break down and aggression between adults became less frequent. Boundaries became more flexible and intruding adults were tolerated while flying through adjacent territories. By 15 July, when most young birds had left the study area, territories had completely broken down.

In summary, the data indicate adult-adult interactions are more intense early in the nesting season, and as the season progresses, defense of territorial boundaries fades. Aggressive behavior is stimulated during periods of excitement such as human disturbance.

Adult-Young Aggressions in Prairie Falcons:

As the young started to fly around the area, aggressive interactions between these young and adults on adjacent areas were observed. This aggression was intense and usually involved both defending adults. Attacks on intruding young were repeated until the young bird either left the area or was reduced to complete submission on the ground. On several occasions, the intruding young lost feathers from repeated contact with defending adults. On one occasion, a young intruder dropped about 6 m as if stunned, partially recovered, but then spiraled to the ground with legs hanging. On another occasion, a young bird was driven down to a ledge, and the adults continued to dive at the young bird until one adult grabbed the young with talons and dragged it off the ledge. The young then dropped to a lower ledge and the adults departed.

Adult prairie falcons appeared to be able to differentiate between their own young and intruders. On 30 June, an alien young bird landed among the fledged young at a neighboring scrape. The fledglings did not show aggression toward the intruder, as mutual preening occurred. When the adults occupying that territory returned, they immediately attacked the alien chick.

Tolerance between territorial adults and intruding young appears to vary with the pair. One pair of prairie falcons attacked only when alien young neared their scrape or when they were excited or feeding. Another pair of prairie falcons flew out of their territory to attack "intruding" young. Several times, this pair pursued a young bird into an adjacent territory or across the canyon. On one occasion, they initiated an attack on a young bird 300 m from the cliff face. This was much farther than any aggression shown toward adults.

On one occasion, we observed an aggressive act toward a pair's own young. This incident occurred shortly after the young had fledged. The female, with prey, landed near the fledged young. The young accepted the prey. The female then departed but immediate-

ly circled and started diving at the fledgling and drove it from the prey. The young bird became submissive and retreated beneath a rock while the female continued to circle. At this time, the male appeared with a prey item, which the young bird also accepted. After the male departed, the female resumed her attack and finally took this second prey item from the young bird and flew to a perch.

In summary, aggressive tendencies are shown toward alien young in a pair's nesting territory. The intensity of this aggression appears to vary between pairs. Adult birds can differentiate between their own young and intruders, and usually attack intruding young birds.

Post-Fledging Mortality:

One of the prairie falcon chicks under close observation disappeared on 24 June. The bird had fledged on 17 June but had not moved far from the scrape. Also on 24 June, a fledged prairie falcon (different from the one above) was found at our camp. This bird was fed and released near the canyon rim. Three days later, another prairie falcon chick was found in camp. This may have been the same bird. Again, the bird was fed and released. The next day, the same bird (identified by condition and feather markings) was back in camp. The bird was in an advanced stage of starvation and showed no sign of aggression. This time, the bird was not released and we started a feeding program.

On 15 July, we found an approximately 55-day-old prairie falcon dead beneath a cliff face in the study area. On the same day, another dead juvenile approximately 55 days old was found at our camp. Neither of these birds had any apparent wounds but their emaciated condition suggested they had starved. At approximately the same time, Dr. Thomas Dunstan, a BLM contractor working in the area, found one of his radioed birds dead by the river, approximately 400 m from our observation cliff. Mr. John Doremus, a BLM research technician, also reported young prairie falcon remains in golden eagle nests at that time.

Not enough information is available to form any positive conclusions about the causes and extent of post-fledging mortality in prairie falcons, but the observations indicate additional studies are warranted to document the rate of mortality in prairie falcons between the time of fledging and the time they leave the Birds of Prey Natural Area.

Prey Analysis:

At present, laboratory work is continuing on pellet analyses and filmed observations of feeding visits. Lists of prey and estimated quantities will be compiled for different methods and compared.

We will use these collections as a basis for next year's work. Techniques of camera placement, film speed, and pellet collection have been modified for the nest field season.

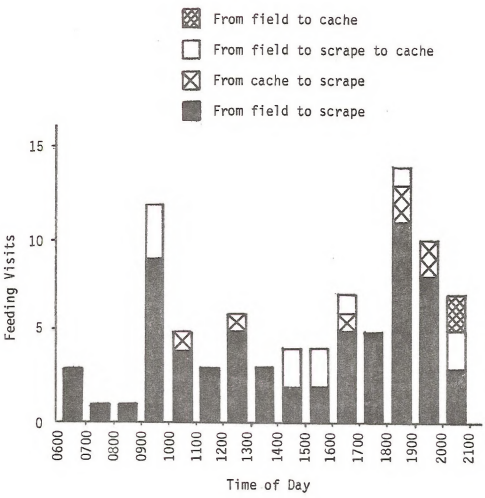
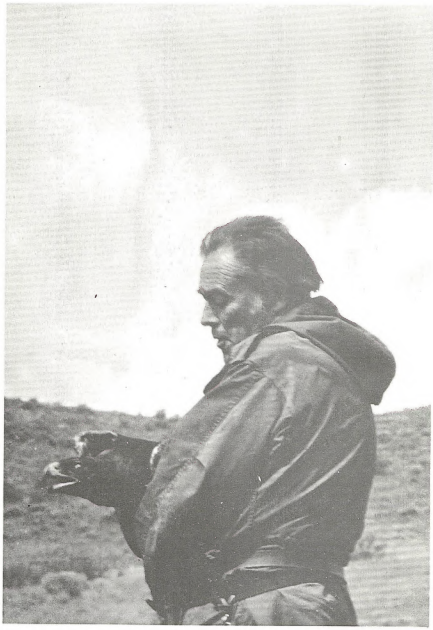


Fig. 1. Relationship of feeding visits to time of day at one prairie falcon nest.



Morlan Nelson, Private Consultant Study VI, holding golden eagle.

Title: Inventory and analysis of critical peregrine falcon (Falco peregrinus) habitat in regards to possible reintroduction in Idaho

Contractor: Mr. Morlan Nelson

Project Support: U.S. Department of the Interior, Bureau of Land Management Contract No. 11010-CT5-10

Objectives:

1. Identify and delineate areas considered critical peregrine falcon habitat, both in a written description and on maps.

2. Recommend habitat management alternatives for these areas in relation to the Bureau of Land Management's planning system.

3. Identify historical peregrine falcon nesting sites on BLM land and report the present occupancy and/or reproductive performance.

4. Analyze the feasibility of reintroducing peregrine falcons on the sites studied and ascertain the order of priority of each site in regard to reintroduction considering nest site availability, disturbance factors, habitat alteration and available prey composition.

The sites are listed in the priority recommended. The reasons for this priority are stated for each location. All slides for these sites carry a key number which corresponds to the name of the area.

(1) Snake River Birds of Prey Natural Area

This site is located directly south of Kuna, Idaho on the Snake River within the boundaries of the Snake River Birds of Prey Natural Area (BPNA).

This site is listed in first priority because a female peregrine has lived there four years. The bird had some immature feathers the first year seen (1972) but was in adult plumage, thus it should be six years old at this time. She has found the food base needed for reproduction but has not been able to find a mate. This site is typically peregrine except for the prey base which may have to be changed to an acceptable level. An important factor in favor of this site is that it is in the BPNA; which affords great protection and opportunity for observation or research.

The nesting cliff, located on the north side of the river, has a southern aspect and a vertical exposure of 600 feet or more. Cliffs on both sides of the river offer excellent nesting opportunities and the female peregrine visits them regularly and could nest on either side if she found a mate. The cliff rock is lava or basalt with lenses of scoria or other material softer than lava. It is ideal cliff material. It is possible that a peregrine nest on the big, south facing cliff would be too exposed to the sun; in which case, a shade could be built to protect the nest scrape. This type of structure has been successfully used for peregrines in other countries.

The prey base is marginal for peregrines but improves each year due to higher rain and snow fall in the region. Observations of other peregrine eyries in the inter-mountain west show that they seldom capture ground squirrels (Spermophilus spp.) traditional prairie falcon (Falco mexicanus) prey. My studies of peregrines in captivity and in the wild indicate that they would never make significant use of ground squirrels even if trained to do so by adult prairie falcons. The peregrine behavioral instincts run very strong to aerial quarry. If a successful attempt was made to put young peregrines under foster parent prairie falcons, I believe their natural bird hunting characteristics would prevail. I also believe that they would select their own species to mate with regardless of species of foster parents. A classic example is the peregrine living at this site now; she has not mated with any of the prairie falcons, which are abundant in the area. It apparently takes stress greater than can be produced in wild populations to make falcons of different species mate.

During the past 28 years, I have made casual observations of this site and done detailed work with some prairie falcon eyries in the immediate area and peregrines have been observed in the area during winter and migration periods for about half of these years. No nesting birds of this species have been seen here, but in similar habitat forty air miles to the west there were nesting birds up until 1952. The status of this site is unknown; peregrine falcons may still be there, or back after extripation as no ground search has been made.

The Birds of Prey Natural Area site has maximum chance for being successful for several reasons: the area is periodically patrolled; the cliff rock is extremely dangerous and not good for climbing; the expanse of the cliff area is so great that natural protection is very good; there is a minimal chance for land use changes in the future that would affect this species; personnel with specialized knowledge on raptors are available to conduct research and make observations on any re-introduction attempt and could formulate management plans for the future; prairie falcons to serve as foster parents are locally abundant for such an attempt; experienced falconers are available if the "hack back" or "flying at hack" method were used to introduce the birds to the canyon. The general habitat, pigeons in the canyon, and increasing prey base resulting from more precipitation, make the area marginal but useful for peregrines at this time.

(2) Shoshone Falls

The general area is two miles east of the city of Twin Falls on the Snake River. There are BLM lands adjacent to the canyon but the majority of the area is privately owned. It is the second priority site because the protection problem is far greater than site number #1 and reasonable control of the area is difficult. It is not a remote site but from the standpoint of habitat, it is excellent.

The cliffs in the area are high and vertical in nature. They vary from 400 to 600 feet in height and offer both south and north exposures for nesting. The general canyon here is deep and narrow offering excellent opportunities for falcons to hunt from the cliffs over the gorge. The cliffs are lava or basalt with changing strata offering a large array of nesting sites. If a pair of peregrines took up a site exposed to the sun, a shade could be built for protection.

Prey populations in this area are the best of any site described. Pigeons (Columba livia) in great numbers live in the canyon for over ten miles in each direction from the site and feed in the surrounding area. Farm lands all around the area provide habitat for other birds which can supplement the pigeons. Prey is so abundant that the area is above the marginal classification. Dr. Tom Cade, from Cornell University, checked this site and was amazed that peregrines did not already live there. However, before the feral pigeons became so numerous this area was not any better than the remainder of the Snake River Canyon to the west as the dry environment did not provide a prey base before irrigation.

There are very few prairie falcons and other raptors living in this reach of the canyon. One pair nests above Derk's Lake about one mile to the east. Based on limited observation, these birds do not significantly feed upon pigeons, but observation in the breeding period will be necessary to confirm this. In winter and during annual migration there are many birds of prey attempting to take the pigeons but with little success as they can escape into small holes in the walls

of the canyon. I have observed prairie falcons wintering in the canyon capturing starlings in farm land and carrying them to the canyon. Golden eagles (Aquila chrysaetos) have nested about one mile west of the falls but I do not know if they have been there the last two years. A red-tailed hawk (Buteo jamaicensis) lives close to Shoshone Falls and was there in 1975. There would be little competition for peregrines in this area from other birds of prey feeding on the same prey base.

In recent years, sport shooting of the pigeons was stopped. There is very little shooting along the canyon now, although ¼ mile back, clay pigeons are used. This isn't a significant problem as the canyon is deep. There are houses on the edge of the cliffs in some areas but because the canyon is vertical, people stay back from the edge. The bottom of the canyon is mostly undeveloped but a golf course has been built in one area. Rock climbing is not a problem as the lava rock is loose and dangerous and several persons have been killed in the area. The extent of the canyon cliffs are so great there would be no problem protecting a site whereever it was chosen by the falcons. No agricultural changes are possible since no arable soils are left in the area. However, one of the proposed sites for the new Twin Falls airport is located 1 mile north of this site.

(3) Duck Valley

The general area is the northeastern edge of Duck Valley. The suggested cliff is north and east of the town of Owyhee just over the Nevada state line into Idaho.

This is the third priority site because it is on the Duck Valley Indian Reservation, which could result in control problems and it is so far from Boise that trained research personnel would have a problem making continuous field observations. However, it is a remote site and the shooting factor and human disturbance problems are minimal. The cliffs are high above the valley and very extensive (over a mile in length) resulting in good natural protection.

The west facing cliff is a volcanic rim rock over 700 feet above the valley floor with vertical rock outcrops running from 75 feet to 150 feet. This cliff has a great number of nesting possibilities and is very remote and has limited access to the base or top. The entire area is at the highest elevation of any site described; varying from 5,500 feet to over 7,000 feet. The elevation is favorable because of cooler temperatures and results in a greater variation in prey species for peregrine falcons. Duck Valley has many swampy areas large enough to be attractive to peregrines. From this site one can see all of Duck Valley which would give birds the visibility they need for aerial prey. The prey species available in this area are the most varied of any sites described due to the elevation and the soil types. There are many small ponds caused by the Owyhee River and irrigation in Duck Valley backing up water behind the gorge. There is no possibility of land use changes in the future that would change the prey base.

In 1949, I observed peregrines in Duck Valley during the nesting season. They were seen north of the proposed site but in the general area and at the time I felt they were using the cliff described but did not go up to check. There have been other occasional observations of peregrines in Duck Valley but no confirmed nesting records.

The day the cliffs were photographed, Mike Kochert, Chief Raptor Research Biologist, BLM, Boise observed a large falcon above this cliff that he was not able to identify positively. He felt it was possibly a peregrine but at the extreme range was not certain. It was a large falcon; however, I have observed prairie falcons on the cliff in recent years.

(4) C. J. Strike

The general area is due north of Bruneau on the Snake River arm of C. J. Strike Reservoir on the very eastern edge of the gorge that starts at the dam and opens up to the flats on the upper end of Strike Dam's backwaters.

The site is fourth in priority because while it is similar to the Birds of Prey Natural Area site it has several practical problems: (1) it is not in the Birds of Prey Natural Area; (2) the gorge is not as deep as the others described, running around 300 to 400 feet; (3) the shooting disturbance factors are higher than at any of the other areas described as there is a great amount of fishing and hunting here. Duck hunting would occur after peregrines would migrate from the area but rock chuck hunters would pose a problem as do some early fishermen who carry guns. There are many visitors from the Mountain Home Air Force Base in the spring who shoot many types of firearms, but this does not seem to be a problem for the many prairie falcons living there now.

The lava cliff has an abundance of nesting sites and is about 100 to 150 feet high. The river runs almost east and west which makes it possible to nest on any exposure. If the birds did pick a south exposure, a shade could be provided without too much trouble. The cliffs run for several miles back towards the dam to the west and the entire area is possible peregrine terrain.

Prey species here are similar to the first site but the falcons would have more room to hunt because of the backwater flats and swamps on both the Snake and Bruneau arms of Strike Dam. The prey base is close to the nesting sites. Prairie falcons are common and one or two golden eagles are close enough to be considered, but there would be no more competition here than at the Birds of Prey Natural Area site.

Migrating wintering peregrines do use this area. On several occasions peregrines have been observed during April and May but there is no authentic record of them nesting there, though it is possible. In 1948, I did check out what seemed to be an authentic nesting pair and found the birds but not the eyrie. They were seen on the Bruneau arm but at the time I felt they nested to the north near the cliffs

described. There was not enough time to check the sighting thoroughly, but I suspect there was a pair there, or somewhere in the area in 1948.

The general area is either BLM or other National Resource Lands. Land use changes are planned adjacent to the area but they would not be significant to nesting peregrines.

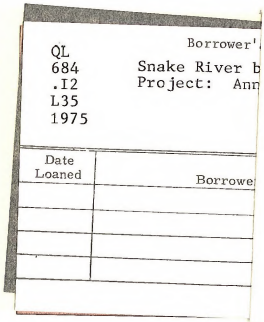
(5) Owyhee Canyon at Duck Valley

The fifth site is located on the northwest side of Duck Valley where the Owyhee River forms a gorge. The cliffs overlook Duck Valley only at the mouth of the gorge as the river makes a sharp turn to the north cutting off the view of the valley. These lava cliffs are 200 to 300 feet high.

This site is recommended as my fifth choice because while it is remote, it does not have as desirable a relationship between cliffs and hunting areas as the other sites and the gorge may not be deep enough to generally attract peregrines. However, the cliffs offer many scrape possibilities in any exposure. Similar to the other sites, a shade could be placed on the cliff if the birds chose a scrape exposed to the sun. The hunting possibilities are poor for peregrines as the gorge is too narrow and there is not enough elevation differentials.

An adequate prey base is present in Duck Valley; which is the same at site number 3. The rim rock on the cliff at site 5 is much lower in elevation than at site number 3 which is an advantage because it helps to off-set the poor condition in respect to the hunting area since the altitudinal distance between hunting area and eyrie would be less. A disadvantage is the top of these cliffs is the terrain level and there is no seasonal elevational differential. At site number 3, the terrain slopes to 9,000 feet yielding a wide range of juvenile birds coming off their nests at different times and elevations that can be easily caught by the falcons at different parts of the season.

Observations in this area are the same as those made at site number 3. Peregrines have been seen in the area but no eyries have been located. Prairie falcons and golden eagles are common raptors in the Owyhee Canyon but they are not as numerous as in the Snake River. The human disturbance factor at site #5 is very low. It is difficult to get to the canyon and it is on the Duck Valley Indian Reservation. Land use changes are very remote. The high water and rocky soils near the north end of the valley are the limiting factors and most of the area that can be irrigated is under production. Recreation potential here is not a problem since the area is not generally suited to recreation.

Townsend ground squirrel with radio transmitter collar and ear tag.

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